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UNITED STATES
DEPARTMENT OF THE INTERIOR
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MULTIPLE-SHIFT MECHANICAL MINING IN SOME BITUMINOUS COAL MINES. PROGRESS REPORT 2

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BY

ALBERT L. TOENGES AND FRANK A. JONES

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

MULTIPLE-SHIFT MECHANICAL MINING IN SOME BITUMINOUS COAL MINES. PROGRESS REPORT 2 [1]

By Albert L. Toenges[2] and Frank A. Jones[3]

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INTRODUCTION

This report is the second of a series describing methods and systems of mechanical mining where operations are conducted on more than one shift. The first report, Information Circular 7014[1] describes mining operations at 14 mines and the present paper describes operations at 11 additional mines. The purpose of this study is to analyze the advantages and disadvantages of the various types of equipment and mining systems now used where more than one shift is worked per day. Physical conditions vary in different and in the same mining districts and determine, together with economical considerations, the systems of mining and the types of mechanical loading equipment to be used. The information presented in this paper may be helpful to operators or others who may contemplate installing a mechanical mining system.

The equipment used in the mines described comprises conveyors, scrapers, mobile loaders, mobile conveyors, and combination of these types. The description of the mining systems and practices at the mines investigated is detailed only as they relate to and affect mechanization. In computing the operating data in mines that are not totally mechanized, employees not working directly on production have been charged to output from mechanized sections in proportion to the percentage of mechanization. The operating data for comparing various systems are for an average working day, as the number of men working on idle days varies greatly in different mines.

Acknowledgment

The information used in preparing this paper was obtained through the courtesy and cooperation of the officials of the companies whose mines are described. The consent of each executive was obtained to publish the data and their accuracy was verified.

DESCRIPTION OF MINES

Mines have been numbered beginning with No. 15, because the last mine described in Progress Report 1, Information Circular 7014, was No. 14.

Mine No. 15

The average daily production from mechanized sections of the mine is 1,140 tons, which is approximately 81 percent of the total output (1,400 tons). The coal bed averages 9 feet thick. At places the bed contains bone partings that vary in thickness. The roof consists of a stratum of sandstone that averages 8 inches thick and a stratum of sandy

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[1] Toenges, Albert L., and Anderson, Robert L., Multiple-Shift Mechanical Mining in Some Bituminous Coal Mines. Progress Report 1: Information Circular 7014, Bureau of Mines, 1938, 56 pp.

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shale above the sandstone. The bottom is hard shaly sandstone. The bed is faulted in some places in the mine and the extent of the mine working is sometimes limited by these faults. The dip of the bed ranges from 14 to 20 percent in a westerly direction.

Mining Methods

The mine opening is a slope that consists of haulageway and aircourse driven in a southwesterly direction across the dip. Both the room-and-pillar and long-face systems of mining are used. The mine is developed with main entries turned off the main slope and driven along the strike on a slight grade to facilitate haulage and drainage. The interval between main entries averages 1,500 feet. These entries comprise three headings driven 9 feet wide on 50-foot centers. The upper heading serves as the aircourse, the center heading is the haulageway, and the lower one is the drainage heading. Panel slopes are driven down the dip off the main entries and rooms usually are turned off one side of the slope along the strike of the bed. The slopes consist of two headings driven 11 feet wide on 50-foot centers. Rooms are on 55-foot centers and 28 feet wide. The length of rooms averages 600 feet, which is the width of the coal panel between slopes.

In part of the mine where long-face mining is used, face entries are turned off the slope in pairs on 50-foot centers. The distance between pairs of face entries depends upon local conditions in the mine but usually ranges from 100 to 250 feet.

Room pillars usually are extracted by hand mining on the retreat from a panel. Approximately 20 percent of the mine output is from pillars. Refer to figure 1 for system of mining.

The mechanical loading equipment consists of 6 power shovels, 2 track-mounted mobile-type loading machines, a longwall face conveyor, and shaking conveyor with self-loading heads.

The power shovels and mobile-type loading machines are used in rooms. Where conveyors are used along long faces, the coal is loaded by hand. Development is driven during the summer with shaking conveyors with self-loading heads.

Room-and-Pillar Mining (Fig. 1-A)

Cutting is done in the coal on the bottom with shortwall cutting machines having an 8-1/2-foot cutter bar. A track-mounted cutting machine equipped with a 9-foot cutter bar is used in one section of the mine. This machine both cuts the bottom and shears the face at the lower rib of the working place. Water is used on the cutter bar of all cutting machines. One cutting machine is assigned to two loading machines, and two loading machines work in six rooms on a panel.

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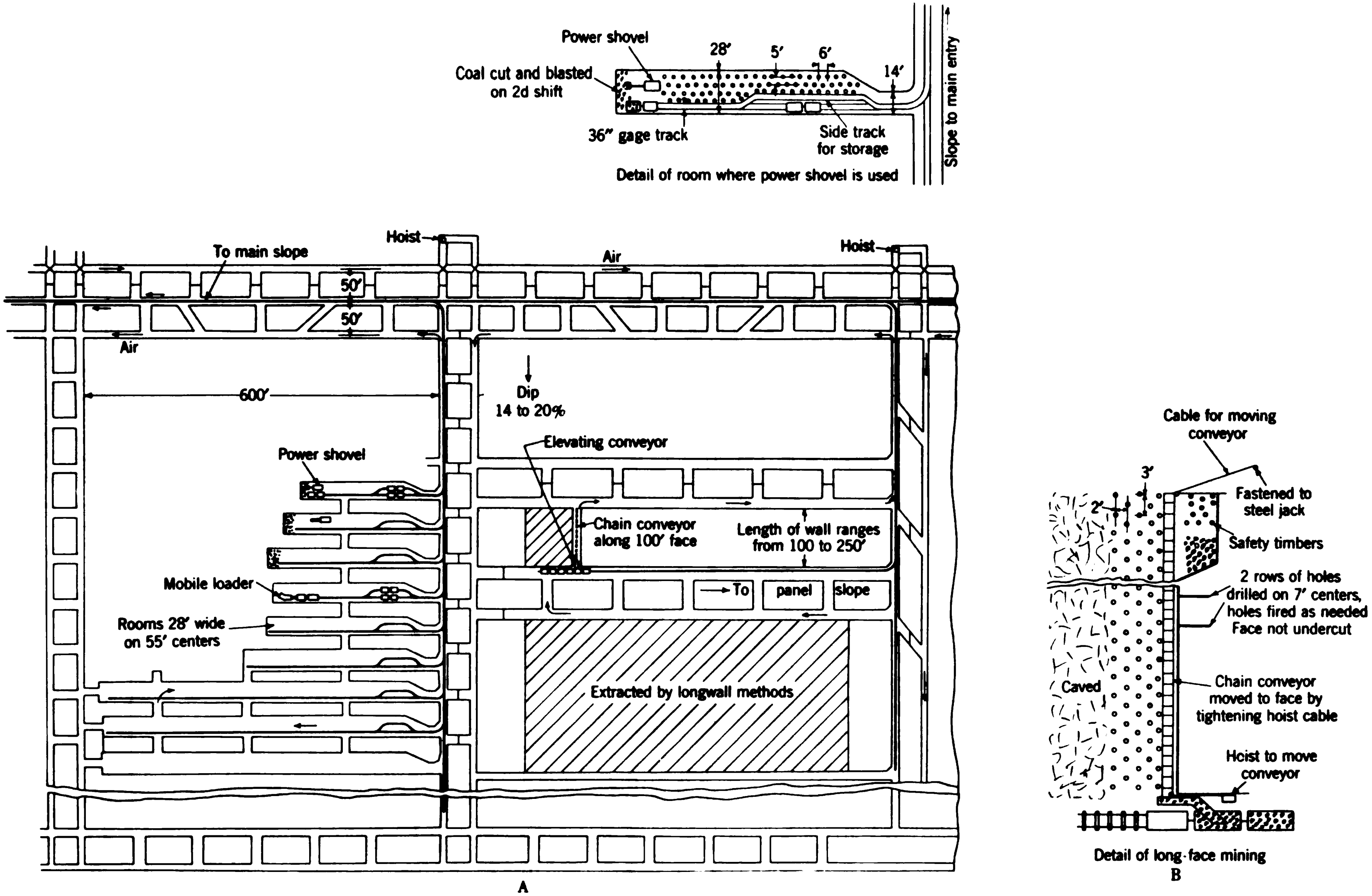
Power shovel
Coal cut and blasted on 2d shift
28′
5′
6′
14′
36″ gage track
Side track for storage
Slope to main entry
Detail of room where power shovel is used
Hoist
To main slope
Air
Hoist
50′
50′
Air
600′
Dip 14 to 20%
Elevating conveyor
Power shovel
Chain conveyor along 100′ face
Length of wall ranges from 100 to 250′
Mobile loader
To panel slope
Rooms 28′ wide on 55′ centers
Extracted by longwall methods
A
Cable for moving conveyor
3′
2′
Fastened to steel jack
Safety timbers
2 rows of holes drilled on 7′ centers, holes fired as needed
Face not undercut
Caved
Chain conveyor moved to face by tightening hoist cable
Hoist to move conveyor
Detail of long-face mining
B

Figure 1.–Mining method at mine No. 15

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The faces are drilled with an electrically operated auger-type drill. Four holes are drilled in a 9-foot place, two holes 12 inches down from the roof near each rib and two holes approximately 2-1/2 feet above the kerf, one 4 feet from one rib and the other about 18 inches from the other rib. Holes are drilled to within 6 inches of the back of the cut. Six holes are drilled in the face of a 28-foot place - three holes about 12 inches from the roof (one at each rib and one in the center) and three holes approximately 2-1/2 feet above the kerf (one at each rib and one in the center). Generally, the holes are charged with black powder in stick form. An average of 5.80 tons of coal is produced per pound of explosive in room and entries. The falls are sprinkled with water before and after shooting to lay the dust.

Four rows of timbers are set in a room with timbers set on 6-foot centers along the length of the room. Safety timbers are set where required. Approximately one prop is used per 18 tons of coal produced.

The working places are prepared on one shift and the coal is loaded on the following shift.

Cars, which have a capacity of 3,500 to 3,800 pounds of coal, are transported to and from the loading machines by horses or mules, usually in trips of two cars. A sidetrack is located in each room for storage of loaded and empty cars. Each panel slope is equipped with an electric hoist, which transports cars to and from the working places in trips of six cars. A sidetrack is situated in the main entry at the head of each panel slope, and loaded trips consisting of 18 cars are hauled to the main slope parting or sidetracks by electric trolley type locomotives. The trips are transported on the main slope by a 600-horsepower steam hoist to the tipple.

A slope panel in which two power shovels are operated consists of the following men:

Classification	Units	First shift	Second shift	Total
Power-shovel men (3)	2	6	-	6
Drivers (1)	2	2	-	2
Cleanup men (1)	2	2	-	2
		10		
Machinemen	1	-	2	2
Drillers	1	-	2	2
Timbermen and trackmen	-	2	2	4
Hoisting engineer	-	1	-	1
Rope rider	-	1	-	1
Foreman	-	1	-	1
		15	6	21

A track-mounted mobile loading machine uses two less men - one less on loading machine and no cleanup man.

All electric power used underground for cutting, drilling, and loading is 440-volt, 60-cycle, 3-phase, alternating current. Direct current is used for locomotive haulage and is 250 volts. All panels are equipped with safety electric switch boxes that cannot be opened when the current is on the line. Underground transformer stations are fireproof with automatic fire doors.

Long-Face Mining (Fig. 1-B).

A wall is opened between two pairs of long-face entries by driving a connection or upset between the entries. The extraction from the face or wall is toward the panel slope. The length of face ranges from 100 to 250 feet. The face is not undercut, but the coal is shot off the solid. Two rows of holes, one 12 inches from the roof and the other 24 inches above the bottom, are drilled on 7-foot centers and staggered across the face. These holes are charged with pellet powder and fired electrically, two holes being shot at a time. The holes are always shot toward the open end, and an average of 17 tons of coal is produced per pound of explosive. The conveyor extends the length of the face and usually is placed against the solid coal. The coal is loaded by hand onto the conveyor, and an average of 135 cars (3,800 pounds each) is loaded per 7-hour shift from a 100-foot face. The face advances approximately 7 feet per shift.

The conveyor is the drag type and is moved as a unit by an electric hoist equipped with a steel cable extending the length of the conveyor and attached to it. Refer to figure 1-B. As the cable is drawn tight, the conveyor moves toward the face to a new position.

The action of the roof is controlled by five rows of timbers set 2 feet apart with timbers set on 3-foot centers and staggered. These five rows of timbers are set back of the conveyor at each move, and then the timbers beyond the first five rows are pulled a row at a time. The roof generally caves back of these five rows of timbers, and the weight of the roof over the mined area is not transmitted to the face. Safety timbers are set along the face as required with the extraction of the coal. An average of 1.5 tons is produced per prop in this work.

The coal passes from the face conveyor to an elevating conveyor and then into cars placed in the entry. The cars are transported to the panel slope in trips of six cars by an electric locomotive.

The cycle of operation for this long face is drill, shoot, load, and set safety timbers as needed, until coal for a depth of 7 feet has been extracted from the wall. The conveyor is then moved ahead and five rows of timber are set back of the conveyor. The rows of timbers placed for the previous position of the conveyor are pulled, and the roof is permitted to fall back of those breaking timbers.

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The crew for a 100-foot long face conveyor section is as follows:

Classification	First shift	Second shift	
Motorman................	1	-	
Loading head man.........	1	-	
Operator................	1	-	
Timbermen...............	2	-	
Loaders.................	7	-	
Shot-firers and drillers	-	2	
Moving conveyor, timbering, and pulling timbers	-	12	
Total men on crew.......	12	14	26

The men employed on mechanized mining during a 24-hour period are as follows:

Classification	Units	First shift	Second shift	Total
Underground:				
Loading-machine units..................	8			
Loaders...........................		30	-	30
Machinemen, drillers, trackmen, and timbermen....................		-	22	22
Drivers, cleanup men, hoisting engineers, rope riders, timbermen, and trackmen...............		24	-	24
Supervision.......................		4	-	4
Total men chargeable to loading machines.........................		58	22	80
Conveyor units........................	1			
Loaders...........................		7	-	7
Timbermen.........................		2	-	2
Operator, car trimmer, and motorman.........................		3	-	3
Shot-firers and drillers..........		-	2	2
Moving conveyors, timbermen, and prop pullers.....................		-	12	12
Total men chargeable to conveyors		12	14	26
Total underground men chargeable to mechanized production...............				106

Classification	First shift	Second shift	Total
Other underground employees:			
Rope rider	1	-	1
Switchman	1	-	1
Motormen	2	-	2
Brakemen	2	-	2
Roller man	1	-	1
Pumper	1	-	1
Sprinklers	2	-	2
Shot-firers	-	4	4
Fire boss	-	1	1
Total other underground employees	10	5	1/15
Total chargeable to mechanized production			12
Surface:			
Hoisting engineer	1	-	1
Power plant	2	2 (and 1 on third shift)	5
Tipple	16	-	16
Mechanics and shopmen	13	-	13
Miscellaneous	1	-	1
Supervision	1	-	1
Total surface	34	2 1	1/37
Total chargeable to mechanized production			30
Total employees chargeable to mechanized production			148

1/ Employees chargeable to both hand and mechanized production.

Summary

Mechanization, percent		81
Average daily production from mechanized units, tons		1,140
Loading machines, tons	925	
Conveyors, tons	215	
Number of units:		
Loading machines		8
Conveyors		1
Number of loading machine shifts per day		8
Number of conveyor shifts per day, including preparation of working place		2
Average number of men per loading machine per day		10
Average number of men per conveyor per day		26
Man shifts per day on mechanized units		106
Loading machines	80	
Conveyors	26	
Average tons per day per man on mechanized units		10.
Loading machines	11.56	
Conveyors	8.26	
Total number of employees underground chargeable to mechanized production		118
Average tons per day per man underground		[illegible]
Total number of employees chargeable to mechanized production		148
Average tons per day per man employed		7

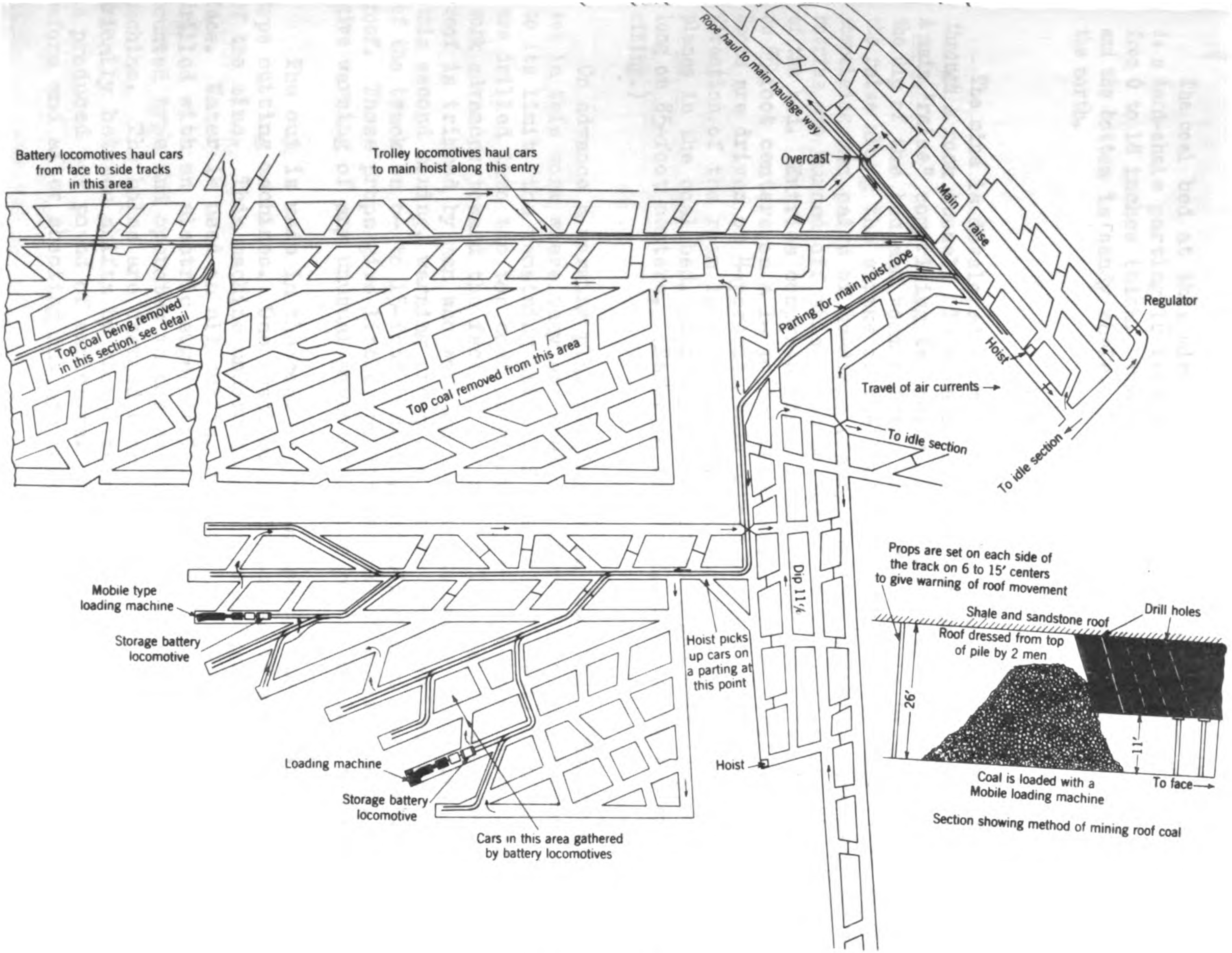
Rope haul to main haulage way
Overcast
Main raise
Regulator
Hoist
Battery locomotives haul cars from face to side tracks in this area
Trolley locomotives haul cars to main hoist along this entry
Parting for main hoist rope
Travel of air currents →
To idle section
To idle section
Top coal being removed in this section, see detail
Top coal removed from this area
Dip 11%
Mobile type loading machine
Storage battery locomotive
Hoist picks up cars on a parting at this point
Hoist
Loading machine
Storage battery locomotive
Cars in this area gathered by battery locomotives
Props are set on each side of the track on 6 to 15' centers to give warning of roof movement
Shale and sandstone roof
Drill holes
Roof dressed from top of pile by 2 men
26'
11'
Coal is loaded with a Mobile loading machine
To face
Section showing method of mining roof coal

Figure 2 - Mining method at mine No. 16

Mine No. 16

The coal bed at this mine averages 26 feet thick. At places there is a hard-shale parting 16 feet above the bottom of the bed that ranges from 0 to 18 inches thick. The roof is hard sandy shale and sandstone and the bottom is sandy shale. The dip of the bed averages 6 degrees to the north.

Mining Methods

The mine is developed from a main haulageway that enters the mine through a rock tunnel. This main entry is driven on the strike of the bed. A main "raise" comprising two pairs of headings (four) is driven across the dip of the bed and room entries are turned to the right and left off the raise along the strike of the bed. There is another main raise also comprising two pairs of headings (four) that are driven up the dip. Room entries are turned off this raise to the right and left along the strike of the bed. Entries comprise three headings and are driven 16 feet wide on 85-foot centers on a 1- to 1-1/2-percent grade to facilitate haulage. Rooms are driven on 4-percent grade across the dip of the bed. The direction of the room is approximately at right angles to the cleavage planes in the coal bed. Rooms are 26 feet wide and average 950 feet long on 85-foot centers. (Refer to figure 2, which shows the system of mining.)

On advance a working place is driven 11 feet high. Safety props are set in this work where they are needed. After the room has been driven to its limit, the remaining height of the bed (15 feet) is mined. Holes are drilled into the top coal, beginning inside the room neck, and this work advances toward the face of the room. The coal is shot down and the roof is trimmed by men who work on top of the loose coal pile. During this second mining, warning props are set in two rows, one on each side of the track on 6- to 15-foot centers, depending upon the character of the roof. These props give little support because of their length, but do give warning of any unusual movement of the roof. Pillars are not recovered.

The cut is made in the coal at the bottom of the bed with shortwall-type cutting machines. One track-mounted machine is used in some sections f the mine. This machine undercuts and also shears the center of the ace. Water is used on all cutting bars to lay the dust. The faces are rilled with an electric auger drill. One of these drills is the track-ounted type and operates in conjunction with the track-mounted cutting achine. The holes are charged with permissible powder and fired elec-rically between shifts by shot-firers. An average of 3.9 tons of coal s produced per pound of explosive. Faces are sprinkled with water efore and after shooting and are rock dusted.

Mobile-type loading machines are used and the coal is loaded into cars that have an average capacity of 4.1 tons. Generally, two loading machines are assigned to nine working places. An average crew for a loading machine driving first mining in a room comprises the following men:

1 operator
1 helper
2 face men
2 motormen
2 nippers
2 tracklayers
1 bratticeman
1 rock-duster and sprinkler
12

Sometimes this crew is increased to 15 men by the addition of two tracklayers and a sprinkler. The air current is carried to the face from the last crosscut by a line brattice.

Where shortwall cutting machines are used, the crew comprises two men, who cut and drill. The track-mounted machine that is used for both undercutting and shearing is operated by three men. The track-mounted drill crew comprises two men. These cutting and drill men prepare an average of six places per shift under the supervision of a face boss.

Where a machine is loading roof coal, two drillers are added to the crew. A machine working in these places has averaged 500 tons per shift.

Development raises are driven up the dip, a shaking conveyor being used in each heading with a cross conveyor to transport the coal to the cars that are placed in the haulage heading. The crew comprises

1 cutting-machine man } who also
1 cutting-machine man helper } drill
1 face man
1 ratchet man
2 locomotive crew

An average of one 7-foot cut is loaded from each heading per shift, approximately 105 tons from two headings.

Permissible-type storage-battery locomotives gather coal at the working faces and transport the cars to a parting or sidetrack on the entry, and trolley-type electric locomotives transport trips of cars to the main raises. Where the haul is short, the storage-battery locomotives deliver the cars to the raise sidetracks. The trips of loaded cars are lowered to the sidetrack on the main haulage entry by an electric hoist, and from here the cars are transported to the tipple by trolley-type electric locomotives.

Labor employed in 24 hours:

Classification	Units	First shift	Second shift	Total
Underground labor:				
Mechanical loading units	5	64	–	
	3	–	38	102
Cutting machines:				
Track-mounted	1	5	5	10
Shortwall	6	12	12	24
Top drillers		5	4	9
Fire bosses and shot firers				7
Employees chargeable to mechanical units				152
Other underground employees:				
Mechanics		6	4	10
Hoistmen and rope riders		4	–	4
Motormen and nippers day	5	10	–	–
night	3	–	6	16
Tracklayers and helpers		5	–	–
Rollerman		1	–	–
Mason		1	–	–
Pipeman		3	–	–
Sprinkler		1	–	–
Rock-dusters		2	–	–
Timbermen		3	–	–
Miscellaneous labor		6	–	22
Supervision		6	3	9
Total men underground				213
Outside labor:				
Fanmen and lampmen		–	–	4
Watchmen and janitors		–	–	3
Teamsters and truck drivers		–	–	4
Tipple crew		–	–	45
Top men		–	–	10
Weighmen		–	–	2
Shopmen		–	–	29
Pumpmen and firemen		–	–	3
Miscellaneous labor		–	–	10
Superintendent and clerks		–	–	5
Total outside labor		–	–	115
Total all employees				328

Summary

Percent of mine mechanized	100
Average daily production during period, tons	2,400
Number of loading machines operated during period	5
Number of loading-machine shifts per day	8
Average number of men per unit per shift	19.0
Man shifts per day on mechanized units	152
Average tons per day per man on mechanized units	15.78
Total employees underground	213
Average tons per day per man underground	11.26
Total employees, surface and underground	328
Average tons per day per man employed	7.32

Mine No. 17

This mine is 100 percent mechanized. At the time the mine was visited operations were curtailed approximately 50 percent and only two of the four loading units were in use. The tipple operates one shift for each two shifts loading in the mine, and the product of the two shifts averages 1,442 tons.

The coal bed, which outcrops on the side of a mountain, averages 12 feet thick and is generally free of partings, although at some places in the mine there are several inches of "bony" in the bed. The bed dips an average of 12 percent to the east. Local dips, however, are greater in some areas. A number of faults occur in the bed, and the extent of the workings in a section of the mine is limited by these faults. The immediate roof is sandstone, which disintegrates upon exposure to the air. The bottom is also sandstone.

Mining Methods

The mine opening is a drift, which intercepts the coal bed about 1,600 feet from the portal, and the main haulageway continues from this point along the strike of the bed across the property. The main slope, through which the present workings are being developed, is approximately 1-1/4 miles from the portal. The room-and-pillar system of mining is followed. (Refer to fig. 3.)

Entries that comprise haulageway and aircourse are driven 16 feet wide on 90-foot centers. Rooms are turned off the haulage heading, which is the intake of the ventilating circuit, and are driven 24 feet wide along the strike of the coal bed for a distance of 1,000 to 2,500 feet, depending upon conditions encountered. The distance between room centers is 100 feet. Slants or crosscuts are turned on an angle of 30° from the room and are spaced 200 feet apart. Room necks are usually the width of the room, 24 feet, except where there is bad roof, and then they are narrowed to 16 feet in width.

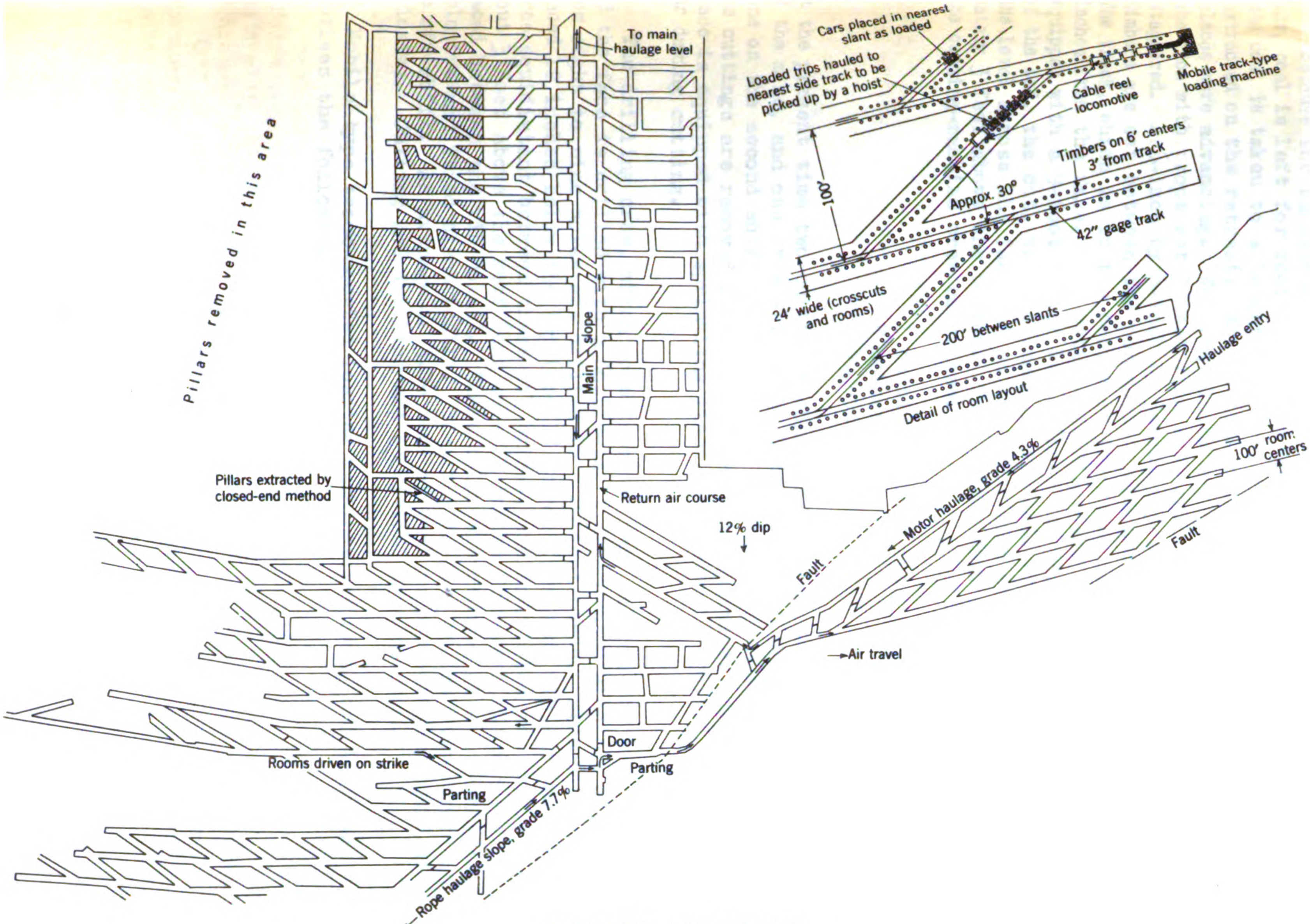
To main haulage level
Cars placed in nearest slant as loaded
Loaded trips hauled to nearest side track to be picked up by a hoist
Mobile track-type loading machine
Cable reel locomotive
Timbers on 6' centers 3' from track
100'
Approx. 30°
42" gage track
24' wide (crosscuts and rooms)
200' between slants
Detail of room layout
Haulage entry
100' room centers
Pillars removed in this area
Main slope
Pillars extracted by closed-end method
Return air course
12% dip
Motor haulage, grade 4.3%
Fault
Fault
Air travel
Door
Parting
Rooms driven on strike
Parting
Rope haulage slope, grade 7.1%

Figure 3.–Mining method at mine No. 17

Because the sandstone above the coal disintegrates upon exposure to air, coal is left for roof in entries and rooms in advance mining. Usually the coal is taken to a height of 8 or 9 feet. Roof coal and pillars are extracted on the retreat. At the time this mine was visited all working places were advancing. Working places are timbered to within 40 feet of the face with props set 3 feet from each rail on 10-foot centers and staggered. A 6-inch by 6-inch by 3-foot cap is used on each prop. Safety timbers are set between the permanent props and the face when necessary. The track, which is in the center of the room, is extended to within 45 inches from the face. The cutting machines are the track-mounted type equipped with a 9-foot cutter bar. Where the place is driven on the strike of the bed, the cut, which is made in the coal at the bottom, extends on the level across the face and at the lower side of the place it is approximately 3 feet above the bottom. This bottom coal is usually not recovered. The cutting-machine crew comprises:

1 cutting-machine man
2 helpers
1 bug-duster.

At the present time two cutting machines are in use, one in each section of the mine, and one crew alternates between the two machines. Cutting is done on the second shift and from 12 to 13 places are cut in a 7-hour shift. The cuttings are removed from the cut prior to shooting. Each working place is equipped with sprinkling lines, and water is applied to the cutter bar during cutting.

The drilling crew, which comprises two men, follows the cutting crew, and the face is drilled with a double-bar track-mounted electric drill. From eight to nine holes are drilled in a 24-foot place. Five holes are placed 12 inches below the top (one 12 inches from each rib and the other three equidistant between these rib holes), and four holes are drilled about 3 feet above the kerf (one hole 12 inches from each rib and two spaced between the rib holes). These holes are charged with a permissible explosive and fired electrically. Blasting is done by two shot-firers on the off shift. An average of 3.74 tons of coal is produced per pound of explosive. Cutting and drilling are supervised by a foreman.

Mobile type track-mounted loading machines are used, and the crew comprises the following men:

1	foreman
1	operator
1	helper
2	motormen
1	nipper for two motors
1	trackman
2	trackman helpers
2	top pickers and timbermen
1	loader follower
12	

The top pickers and timbermen pick down loose roof and timber. The loader follower cleans up the face after the loading machine has left and prepares the place for the track and cutting crew. Two locomotives transport cars to and from the loading machine. From 12 to 13 places are cleaned up per 7-hour shift.

An analysis of the loading performance averages:

32.3	percent of the total time loading,
24.4	percent of the total time switching cars,
17.0	percent of the total time moving between places,
17.8	percent wait for trips,
8.5	percent delays, such as machines off track, broken cable, etc.
100.0	

Track is placed in slants to facilitate car changes. The average maximum distance traveled to make a car change is 300 feet.

Grades in slants between rooms average 7 percent. The loading machines have loaded coal successfully where the upgrade has been 12-1/4 percent. In developing working places along the dip, a slabbing drum on the machine and a jack pipe are used to hold the machine away from the face. Coal has been loaded from dip places where the maximum grade has been 23 percent.

Trolley and reel-type locomotives transport the coal from one side of the mine to the main slope parting in trips of eight or nine cars. On the other side of the mine, the development is from an auxiliary slope, the average grade of which is 7.7 percent. Cars are transported to and from the working places off the slope by rope haulage operated by a 100-horsepower electric hoist. Electric trolley and reel-type locomotives operating in the working places receive cars in the room necks, where there is a parting for storage of loaded and empty cars. Loading machines, cutting machines, and cars are handled in the advance work of the slope by an auxiliary 75-horsepower electric hoist. Cars are transported from this section in trips of four to five cars to a parting or sidetrack off the main slope.

The main slope is 3,000 feet long. Trips usually comprising eight cars are hoisted to the sidetracks on the main haulageway by a 300-horsepower electric hoist. From these sidetracks trips averaging 50 tons are transported to the sidetracks outside the portal, a distance of 1-1/4 miles by trolley-type locomotives. There are two sizes of cars, 3-ton and 6-ton, and the number of cars in a trip depends upon their total capacity.

The sidetracks at the portal, situated approximately 500 feet above the tipple, are used to make up trips, which are lowered in balance over a gravity plane. This plane is 3,300 feet long - 2,000 feet of this

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distance is on a 12-percent grade and the upper 1,300 feet is on a 16-percent grade. The 500-horsepower, 2,300-volt, 3-phase, 60-cycle, alternating-current electric hoist that controls the movements of the trips is of the regenerative type that levels the demand power peaks.

The coal is discharged from the cars by a rotary dump at the tipple. The following men are employed:

Classification	Units	Men	Shifts	Total
Underground employees:				
Loading machines	2	27	2	54
Cutting, drilling, and shooting	1	9	2	18
Total men chargeable to loading machines		36	4	72
Other underground employees:				
Main slope:				
Hoisting engineer		1	2	2
Rope-rider		1	2	2
Parting-coupler		1	2	2
Latch-kicker		1	2	2
Main motor road		2.5	2	5
Trackman and helper		2	2	4
Timberman and helper		2	2	4
Pipeman and wireman		1	1	1
Lampman		1	2	2
Ventilation man and helper		2	1	2
Dummy-maker		1	1	1
Rock-duster		1	2	2
Mechanics		6	2	12
Miscellaneous		4	2	8
Supervision		3	2	6
Total other inside employees				55
Total underground labor				127
Surface employees:				
Tramway		3	1	3
Tipple		8	1	8
Supervision and office		5	2	10
Total, surface and office				21
Total all employees chargeable to mechanized production				148

Summary

Percent of mine mechanized	100
Average daily production, tons	1,442
Number of loading machines	2
Number of loading machine shifts per day[1]	4
Average number of men per unit per shift	18
Man-shifts per day on mechanized units	72
Average tons per day per man on mechanized units	20.0
Total number of employees underground	127
Average tons per day per man underground	11.35
Total employees, surface and underground	148
Average tons per day per man employed	9.74

[1] Tipple days.

Mine No. 18

All of the product of this mine is loaded mechanically. At the time this mine was visited, the tipple was operated one shift for every two shifts loading in the mine, which is equivalent to two loading shifts and one preparation shift during a 24-hour period. The average production of the mine at that time from two shifts loading was 1,750 tons. Normal production in demand periods is 3,000 tons per day.

The coal bed varies in thickness from 12-1/2 feet to 17 feet and is free from partings. The roof immediately above the coal comprises 4 feet of sandstone and the bottom is sandstone. No faults have been found, but local rolls occur in the bed. The dip of the bed is 10 percent to the north and the average thickness of cover is 1,200 feet.

Mining Methods

The coal bed outcrops on the side of a mountain and a rock tunnel was started at tipple height and driven 8,300 feet, where the coal bed was intercepted. From this point a main east and west entry was driven along the strike of the bed across the property and the mine was developed from a main slope driven off the main entry. (Refer to fig. 4.) The original plan of development comprised room entries turned to the right and left off the slope along the strike of the bed, and rooms were driven across the dip of the bed from the haulage entries. A modified room-and-pillar (block) system of mining was followed. Recently the plan of development was changed, and this new development will be described. (Refer to secs. A and B, fig. 4.)

A haulageway is turned at an angle of approximately 50° off the haulage entry from the slope and driven up across the dip. Rooms are driven on the strike. The distance between the center line of rooms averages 82 feet, and slants between rooms are also turned on 82-foot center lines. The haulageway and slants are driven 16 feet wide, and rooms

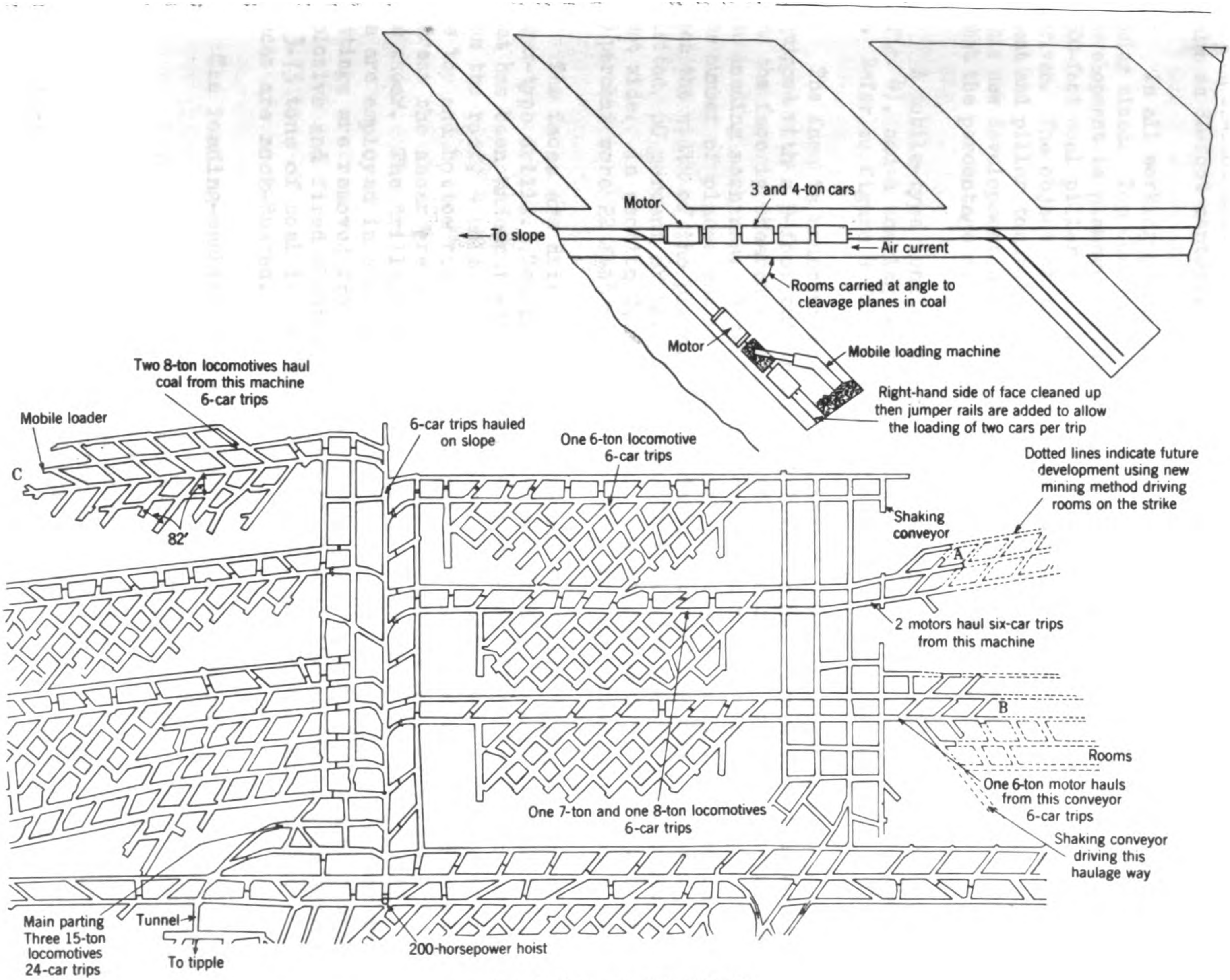
3 and 4-ton cars
Motor
To slope
Air current
Rooms carried at angle to cleavage planes in coal
Motor
Mobile loading machine
Right-hand side of face cleaned up then jumper rails are added to allow the loading of two cars per trip
Two 8-ton locomotives haul coal from this machine 6-car trips
Mobile loader
C
82'
6-car trips hauled on slope
One 6-ton locomotive 6-car trips
Dotted lines indicate future development using new mining method driving rooms on the strike
Shaking conveyor
A
2 motors haul six-car trips from this machine
B
Rooms
One 6-ton motor hauls from this conveyor 6-car trips
Shaking conveyor driving this haulage way
One 7-ton and one 8-ton locomotives 6-car trips
Main parting Three 15-ton locomotives 24-car trips
Tunnel
To tipple
200-horsepower hoist

Figure 4.–Mining method at mine No. 18

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22 to 24 feet wide. In section C, figure 4, rooms were turned across the dip on 82-foot centers and slants between rooms were driven on the strike, also on 82-foot centers.

In all working places at the present time 10 feet of the bed is being mined. Top coal and pillars will be extracted on the retreat. The development is planned so that rooms will be driven 448 feet long. A 500-foot coal pillar will be left and a new section of rooms will be driven. The object of this plan is to provide a balance between development and pillar tonnage on the retreat from a section. The recovery from this new development averages 30 percent, but on the retreat it is expected that the percentage of recovery will be considerably higher.

A mobile-type loading machine was used in each section, A and C (fig. 4), and a shaking conveyor unit was driving the haulageway in section B. Refer to figure 4 for location of other shaking conveyors.

The face is undercut and sheared with a track-mounted cutting machine equipped with a 9-foot cutter bar. A level cut is made across the bottom and the face is sheared at the right rib. One cutting machine serves the two loading machines. Water is used on the cutter bars to allay the dust. The number of places cut by this machine ranges from 6 to 16, depending upon the width of the place. In section A, at the time the mine was visited, 60 percent of the places were 16 feet wide and 40 percent were 22 feet wide. In section C, 35 percent of the places were 16 feet wide and 65 percent were 22 feet wide. The cutting crew comprises three men.

The faces are drilled with column-mounted, electrically-operated, auger-type drills. Generally, 10 holes are drilled in a 22-foot face that has been undercut and sheared: 4 holes about 12 to 14 inches down from the roof, 4 holes about 3 feet above the bottom, and 1 hole between the top and bottom rows and about a foot from the solid ribs. The holes nearest the shear are drilled so that the end of the hole is 3 feet from the shear. The drilling is done by a crew of two men, and usually six men are employed in a 24-hour period. The faces are sprinkled and machine cuttings are removed from the cut. The holes are charged with a permissible explosive and fired electrically by shot-firers between shifts. An average of 3.73 tons of coal is produced per pound of explosive. All working places are rock-dusted.

The loading-machine crew comprises the following men:

1	operator
1	helper
1	faceman
2	motormen
1	nipper
3	tracklayers
1	cleanup man
1	foreman
11	

The track in rooms is laid near the right-hand rib and loading is begun at the right side of the face. As soon as enough of the coal is loaded the track is extended to the face, and the loading machine operates between the track and the other rib. As a rule, two cars can be loaded before it becomes necessary to switch cars.

A time study of several months' duration shows the average performance of the loading machines used in this mine.

Productive Time

	No. 1 loading machine	No. 2 loading machine
Cuts loaded per shift......	6.56	6.25
Cars loaded per shift......	78.58	92.41
Average tons per car.......	3.62	3.56
Tons loaded................	285.16	329.75
Tramming time, minutes.....	43.00	37.75
Percent of total time.	10.3	9.2
Loading coal, minutes......	186.41	147.91
Percent of total time.	44.5	35.1
Changing cars, minutes.....	79.33	90.16
Percent of total time.	18.8	21.4
Getting empties, minutes...	44.26	39.18
Percent of total time.	10.5	9.3
Total productive time......	353.0	315.0
Percent of total time.	84.1	75.0
Nonproductive Time		
Wait for empties, minutes..	4.50	10.25
Percent of total time.	1.1	2.4
Derails, minutes...........	17.42	20.59
Percent of total time.	4.1	4.9
Conflict with other work, minutes..................	4.00	2.17
Percent of total time.	1.0	0.5
Mechanical trouble, minutes	15.58	17.33
Percent of total time.	3.7	4.2
Extending tracks, minutes..	3.25	4.83
Percent of total time.	0.7	1.2
No power, minutes..........	1.17	3.33
Percent of total time.	0.3	0.8
Miscellaneous, minutes.....	21.08	46.50
Percent of total time.	5.0	11.0
Total delays, minutes......	67.0	105.0
Percent of total time.	15.9	25.0

Where shaking conveyors are used the crew comprises the following men:

3	facemen
1	car-trimmer
1	motorman
5	

One foreman supervises the men on two conveyors.

This crew cuts, drills, shoots, and loads the coal. The cut is made in the coal at the bottom of the bed with a shortwall-type cutting machine equipped with a 7-foot cutter bar. The face is drilled with a column-mounted, electrically-operated, auger-type drill. The face is shot with Cardox, a permissible explosive device. The conveyor is the shaking type equipped with a self-loading head. An average of two cuts of coal is loaded per conveyor shift.

Under the present system of mining, little timbering is required on the advance. Where abnormal roof conditions are found, safety timbers are set.

Ventilation is carried to the faces of working places by a line brattice, which extends from the last slant. This brattice is suspended by hooks from a wire, which extends along the roof and is supported by eye-bolts. The line brattice is hung about 4 feet from the rib, and when a machine is working at the face the brattice can be shifted along the wire to provide working space for the machine.

Coal is loaded in cars whose capacity ranges from 2.6 to 4 tons. As a rule the larger-capacity cars are sent to places where coal is loaded by the loading machines. Cars are gathered by trolley and cable-reel locomotives and transported to the slope partings usually in trips of six cars. (Refer to fig. 4.) A 200-horsepower electrically operated hoist hauls 6-car trips up the slope to the parting on the main east and west haulage entry. At this parting the cars are assembled in trips comprising 24 cars, and these trips are transported to the tipple, a distance of 10,700 feet, by 15-ton trolley-type locomotives. All except 1,700 feet (9,000 feet) of this haul is double-track. At the tipple the cars are dumped by a rotary dump.

Electric power is purchased from a public utility company. This alternating current is converted to 250-volt direct current for use by mining equipment by four 200-kilowatt motor generator sets.

The following labor is employed during a 24-hour period:

Classification	Units	First shift	Second shift	Third shift	Total
Mobile loading machines	2	20	20	-	40
Cutting	1	3	3	-	6
Drilling		2	2	2	6
Bratticemen		3	1	-	4
Supervision		2	2	-	4
Shot-firers				5	5
Total mobile loaders		30	28	7	65
Shaking conveyors	2	10	10	-	20
Supervision		1	1	-	2
Total conveyors					22
Employees chargeable to mechanized units					87
Other underground employees:					
Slope engineer		1	1	-	2
Rope-rider		1	1	-	2
Latch-kicker		1	1	-	2
Main-line locomotives		3	-	-	3
Timbermen		2	-	-	2
Trackmen		8	-	-	8
Dispatcher		1	-	-	1
Ventilation inspectors		-	-	3	3
Stopping men		3	-	-	3
Mechanics		4	-	-	4
Pipemen		2	-	-	2
Pumpmen		1	-	-	1
Wiremen		2	-	-	2
Material		1	-	-	1
Dummy boy		1	-	-	1
Greaser		1	-	-	1
Supervision		1	1	1	3
Total other underground employees		33	4	4	41
Total men underground chargeable to mechanization					128
Surface employees:					
Tipple					27
Shop					10
Miscellaneous					13
Total surface					50
Total all employees					178

Summary

Percent of mine mechanized	100
Average daily production, tons	1,750
Number of loading machines	2
Number of conveyors	2
Number of loading machine shifts per day	4
Number of conveyor shifts per day	4
Average number of men per loading machine per shift	16.25
Average number of men per conveyor unit per shift	5.5
Man-shifts per day chargeable to loading machines	65
Man-shifts per day chargeable to conveyors	22
Average tons per day per man on loading machines	23.35
Average tons per day per man on conveyors	10.54
Total employees chargeable to mechanized units	87
Average tons per man per day on mechanized units	20.11
Total employees underground	128
Total employees, surface and underground	178
Average tons per day per man underground	13.67
Average tons per day per man employed	9.83

Mine No. 19

The output of this mine is loaded mechanically with crawler-type mobile loading machines. Approximately 50 percent of the production is from development (entries and room necks) and 50 percent is from rooms.

The coal bed averages 4 feet thick and is overlain with black to gray sandy shale. There generally is a thick stratum of sandstone above the shale. Between the shale and sandstone is usually a thin layer of fire clay which at places causes a separation of the shale and sandstone, resulting in poor roof conditions, and close timbering is required. The bottom is fire clay. Either the roof or bottom of entries is brushed, depending upon local grades in the bed, to provide an average clearance of 54 inches above top of rail.

Mining Methods

The room-and-pillar system of mining is used, and main haulage entries consist of four headings driven 12 feet wide on 30-foot centers. Crosscuts between headings average 45 feet apart and crossovers are driven between two pairs of headings about every 200 feet. At the present time the two outside headings are the intake and the two inside headings are the return in the ventilating system of the mine.

Panel or room entries comprise two headings, and these are turned off the main entries on an average of 400 feet apart. The panel headings are driven 12 feet wide on 30-foot centers. Rooms are turned on 36-foot centers both to the right and left of the panel entries. Room necks are driven 12 feet wide by 12 feet deep and then the room is widened toward the inby side to 24 feet.

The length of rooms ranges from 170 to 175 feet. Crosscuts between rooms average 45 feet apart. After the coal in a panel has been extracted, permanent seals are constructed across the panel heading outside the first rooms. Pillars are not withdrawn.

The coal is cut with shortwall-type cutting machines equipped with either 8-1/2-foot or 6-1/2-foot cutter bars. The cut is made in the coal at the bottom of the bed. The number of places cut per shift ranges from 9 to 14 in narrow work (headings and room necks) and 10 to 12 in rooms. Usually five holes are drilled with an electric auger-type drill in a 24-foot place. Holes are charged with permissible powder and fired with fuse by the driller assigned to a loading unit, after the men have left the mine. An average of 2.1 tons of coal is produced per pound of explosive.

The roof on main entries is timbered with 60-pound rail crossbars placed on supports inserted in hitches cut by a hitch drill. The distance between crossbars averages 3 feet. Rooms usually are timbered with a three-piece timber set, comprising a 2-inch by 8-inch or a 2-inch by 12-inch by 10-foot long cap placed flat against the roof. These caps are supported by two legs with a minimum 5-inch-diameter top placed to permit 8 feet of clearance for the track between the legs. The sets are erected along the center line of the room on 2-foot to 4-foot centers, depending upon the character of the roof. Safety timbers are used at the face as required. Approximately 2.8 tons of coal are produced per prop under average conditions in the mine.

At present the coal is loaded by four mobile loading machines. Usually three of these machines operate in rooms and one in entries and room necks on the first shift, and two operate in narrow work on the second shift. The coal is loaded in cars that have an average capacity of 1.75 tons. An average crew assigned to a loading unit is

1 loading-machine operator
1 loading-machine operator helper
2 cutting-machine men
2 motormen } 3 locomotives for 2 units
1 trip rider }
1 driller
1 mucker
1 timberman
1 tracklayer
1 foreman
12

As no blasting is done on shift, enough places are prepared to meet the requirements of the loading equipment. A haulage locomotive works with each loading machine and places cars as needed. Loaded cars are placed in adjacent rooms, and the maximum average round-trip haul for the locomotives in this service is 250 feet. Another locomotive is assigned to two loading units, and places empties and receives loads nearest the working place where the loading machine is situated. These locomotives transport the coal to the shaft bottom or to sidetracks, depending upon distance of working places from the shaft. The present main-line haul is 3,000 feet.

The coal is hoisted in cars on overturning-type self-dumping cages. The cars have a capacity of 2 tons but average 1.75 tons of coal.

Electric power is purchased from a public utility company and an average of 6 kilowatt hours is consumed per ton of coal.

The following labor is employed in a 24-hour period:

Classification	Units	First shift	Second shift	Third shift	Total
Loading-machine men............	4	8	4	-	12
Cutting-machine men............	4	8	4	-	12
Drillers and shot-firers.......		4	2	-	6
Muckers........................		4	2	-	6
Locomotive crews...............		12	6	-	18
Timbermen......................		4	2	-	6
Tracklayers....................		4	2	-	6
Foremen........................		4	2	-	6
Total men on mechanized units..		48	24		72
Other underground labor:					
Oilers.........................		-	-	2	2
Timbermen......................		10	-	-	10
Tracklayers....................		1	3	-	4
Bratticemen....................		4	-	-	4
Motormen and trip-riders.......		4	2	2	8
Laborers.......................		2	-	2	4
Pumpers........................		1	1	-	2
Couplers.......................		2	1	-	3
Cagers.........................		2	-	-	2
Electricians...................		-	-	3	3
Fire boss......................		-	-	1	1
Foremen........................		1	1	2	4
Total other underground employees		27	8	12	47
Total men underground chargeable to mechanized production					119
Surface employees:					
Hoisting engineers.............		1	1	1	3
Tipple operators...............		2	-	-	2
Yard men.......................		3	-	-	3
Shopmen........................		5	-	-	5
Supervision and office.........					9
Total surface employees........					22
Total employees chargeable to mechanized production					141

Summary

Percent of mine mechanized	100
Average daily production from mechanized units, raw coal, tons	1,080
Number of loading machines	4
Number of loading machine shifts per day	6
Average number of men per unit per shift	12
Man-shifts per day on mechanized units	72
Average tons per day per man on mechanized units	15.0
Total number of employees underground	119
Average tons per day per man underground	9.07
Total number of employees, surface and underground	141
Average tons per day per man employed	7.65

Mine No. 29

The bed, which lies comparatively level, at this mine averages 6 feet thick. The depth of the bed below the surface ranges from 90 to 180 feet. The strata immediately above the bed are hard, sandy shales filled with concretions and boulders, which extend downward into the coal. This condition leaves an extremely rough roof after the coal is removed. Usually the roof is good and requires little timbering.

The bottom comprises 3 or 4 feet of fire clay, below which lies a thick bed of sandstone. The fire clay remains firm except in the presence of water.

Mining Methods

The mine opening is a slope, and main entries, comprising four headings 16 feet wide on 32-foot centers, are driven from the foot of the slope. The headings, crosscuts, and other openings are driven by a crew on both the day and night shift. The coal is loaded by means of a mobile loading machine from these working places into mine cars. Cutting is done in the coal at the bottom of the bed with a 50-horsepower cutting machine equipped with a 7-foot cutter bar. Holes in the face are drilled with an electric auger-type drill and the holes are charged with permissible explosive and fired with fuse by the drillers after the men have left the mine. The coal from development work is transported to the slope bottom in trips of five cars by a 6-ton trolley reel-type locomotive.

The following labor is used on development work on two shifts:

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	Day shift	Night shift	
Loading-machine operator	1	1	
Cutting machine	2	1	(Drilling and cutting done by same two men on night shift
Drilling	1	1	
Laborer (track and timber)	1	1	
Motormen	1	1	
Trip-rider	1		
Foremen	1	1	
	8	6	
Total men on development			14

Panel headings driven in pairs are 16 feet wide on 32-foot centers. Rooms are turned off these headings on 50-foot centers and are driven 30 feet wide. Crosscuts between rooms are driven on 40-foot centers and are staggered so that a solid pillar lies opposite each crosscut. This system of crosscuts allows the tractor-trailer units that transport the coal to run in nearly a direct line to the transfer station from every working place.

Rooms are cut and drilled on shift, but all shots are fired by the driller after the men are out of the mine.

Two loading machines work in panels and rooms and load directly into the trailer units. Usually a 30-foot-wide room will produce from 50 to 60 tons when a 7-foot cut is made in the coal. The haul from the loading machine to the transfer station is limited to 1,000 feet, if possible, so two tractor-trailer units will keep the loading-machine delays to a minimum. When the distance is greater than 1,000 feet, it is necessary to add a third tractor-trailer unit for each loading machine.

Haulage

Units are powered by a 24-cell storage battery, which is charged 8 hours for each 7 hours of use with an additional soaking charge over week-ends and during other idle periods. Ordinarily the battery is given a boosting charge during the half-hour lunch period each working day.

The trailer has a clearance of 6-3/4 inches from the bottom. The top of the tractor clears the roof by an average of 36 inches. The trailer is 12 feet long by 6 feet 6 inches wide and holds 5 tons.

Tractor and trailer units haul the coal mined in panel entries and rooms to a centrally located transfer station. The trailer is equipped with a drop-bottom dump and drops the coal onto a drag feeder, which passes it to a 30-inch belt. This belt, which has a capacity of 8 tons per minute, carries the coal for 61 feet on a 16° pitch and discharges it into 5-ton mine cars. As the cars are loaded the transfer-station operator stops the belt and signals a motorman who shifts the trip or takes a loaded trip of 8 to 10 cars to the 85-ton storage bin at the slope bottom.

The mine cars are a drop-bottom type that dump automatically as they cross the storage bin. The coal is fed from this bin by a reciprocating feeder onto a 36-inch belt, which transports the coal up an 18° pitch to the preparation plant on the surface.

Labor used on sections where the coal is transported by tractor-trailer units is as follows:

	Units	First shift	Second shift	Third shift	Total
Mobile loaders	2	4	-	-	4
Cutting	2	4	-	-	4
Drilling	2	4	-	-	4
Tractor operators	5	5	-	-	5
Transfer-station operator	1	1	-	-	1
Laborers		2	-	-	2
Foremen		2	-	-	2
Total		22			22

Timbering

Usually each place is timbered with a row of timbers on 6-foot centers about 4 feet from each rib. Approximately 30 tons of coal are produced per prop.

Explosives

Approximately 5.53 tons of coal are produced per pound of permissible explosive.

Power

All electric power is purchased from a public utility and is 60-cycle 3-phase alternating-current. It is converted to direct current for mine use. Power used underground for mining machinery, loading machinery, haulage motors, and conveyors is 250-volt direct-current. Power for the loading and cutting machines is distributed to convenient points by rubber-covered cable. The consumption for the mine ranges from 6.5 to 7.3 kilowatts per ton.

Classification of employees

	Units	First shift	Second shift	Third shift	Total	
Underground men:						
Rooms (wide places):						
Loading machine	2	4	-	-	4	
Cutting machine	2	4	-	-	4	
Drillers	2	4	-	-	4	
Tractor operators	5	5	-	-	5	
Transfer-station operator	1	1	-	-	1	
Laborers		2	-	-	2	
Foremen		2	-	-	2	
Total men on room mechanization		22			22	
Development (narrow work):						
Loading machine	1	1	1	-	2	
Cutting machine	1	2	2	-	4	
Driller		1	-	-	1	
Tracklayer		-	1	-	1	
Motormen		1	1	-	2	
Laborer		1	-	-	1	
Trip-rider		1	-	-	1	
Foreman		1	1	-	2	
Total men on mechanical development		8	6		14	
Total men on mechanized units						36
Other underground men:						
Motormen		2	-	-	2	
Mechanics		2	2	-	4	
Laborers (timbermen, trackmen, and oilers)		1	2	-	3	
Main dump hopper		1	-	-	1	
Pumpers		1	1	1	3	
Total other underground men		7	5	1	13	13
Total underground men chargeable to mechanization						49
Surface employees:						
Mechanics		4	-	-	4	
Tipple		10	-	-	10	
Office		2	-	-	2	
Engineer		1	-	-	1	
Top boss		1	-	-	1	
Watchmen		-	1	1	2	
Total surface employees		18	1	1	20	20
Total all employees						69

Summary

Percent of mine mechanized	100
Average daily production (raw coal), tons	1,176
Number of loading machines	3
Number of loading-machine shifts per day	4
Average number of men per unit per shift	9
Man shifts per day on mechanized units	36
Average tons per day per man on mechanized units	32.66
Total number of employees underground	49
Average tons per day per man underground	24.0
Total number of employees, surface and underground	69
Average tons per day per man employed	17.04

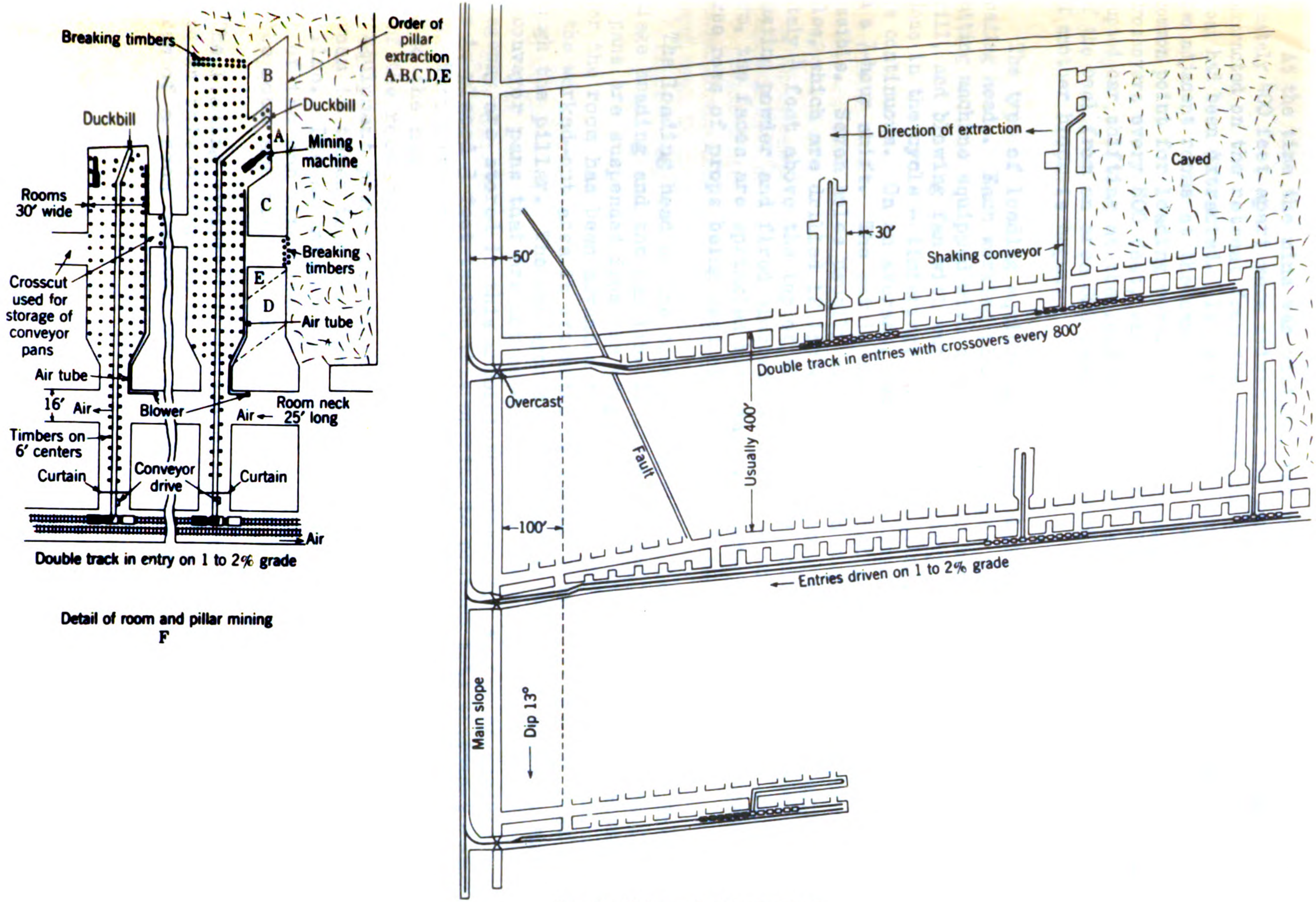
Mine No. 21

The workings of this mine are in two beds of coal that are approximately 40 feet apart. One bed ranges from 5 to 9 feet in thickness and the other ranges from 4 to 14 feet in thickness. Both beds dip approximately 13° to the west. The development in both beds is similar and comprises a main underground slope driven down the dip, with entries turned to the right and to the left off the slope, and driven on the strike with about 1 to 2 percent rise in grade to facilitate haulage and drainage. The interval between entries off the slope is 400 feet. The room-and-pillar system of mining is followed. The slopes in each bed are connected to the surface by rock tunnels and the output is prepared at one tipple.

Mining Methods

Entries, which comprise an air course and haulageway, are driven 16 feet wide on 41-foot centers to the property line or a predetermined boundary. The depth of cover at the present time ranges from 230 feet to 300 feet. Crosscuts are turned off the bottom or haulage heading on 50-foot centers and are driven in approximately three cuts. At 300-foot intervals a crosscut is driven through to the air course. Room necks are turned off the air course on 50-foot centers in line with the crosscut as the heading is advanced. Two cuts are usually taken from a room neck. A barrier pillar 100 feet wide is left between the slope and first room. (Refer to fig. 5.)

When the entry has been driven to the boundary, rooms 30 feet wide are driven up the dip a distance of 375 feet. As a rule, the rooms do not break through the entry above. The 25-foot barrier pillar between the face of the rooms and the upper workings usually is not recovered. When a room has advanced about half its full length, two cuts are taken 15 feet wide for a crosscut on the side of the room toward the slope. The crosscut is completed from the next room. After a room has been driven to its limit, the pillar is extracted on the retreat, except a small pillar stump left at the entry.



Detail of room and pillar mining
F

Figure 5.–Mining method at mine No. 21

At the time the mine was visited, two rooms that were situated approximately 400 feet apart were driven at the same time. The pillars were extracted on the retreat from the rooms and timbers were pulled after the coal had been extracted. It is planned to change this system and drive two adjacent rooms at the same time, using two shaking conveyors with a common point for loading cars. The haulageway is double-tracked, with crossovers every 800 feet, which facilitates hauling and permits uninterrupted car shifting at the loading point of the rooms. Upon the extraction of the coal from an area 800 feet wide by 375 feet long, the development of another block is begun.

The type of loading equipment used is shaking conveyors with self-loading heads. Each working place is equipped with a conveyor, shortwall cutting machine equipped with a 7-foot cutter bar, electric auger-type drill, and blowing fan with tubing for auxiliary ventilation. The operations in the cycle - timbering, cutting, drilling, shooting, and loading - are continuous. On an average, two cuts are loaded from a 30-foot place in a 7-hour shift. The cut is made in the coal as near the bottom as possible. Seven holes usually are drilled in a 30-foot face - four top holes, which are drilled 12 inches from the top, and three holes approximately 4 feet above the top of the kerf. The holes are charged with stick blasting powder and fired electrically. Where working places are dry and warm, the faces are sprinkled with water. Rooms are timbered systematically, three rows of props being used on each side of the conveyor.

The loading head of the conveyor is placed in the crosscut at the haulage heading and the pan line is extended with the advance of the face. The pans are suspended from the props alongside the conveyor by chains. After the room has been advanced to its limit, the pillar between the room and the worked-out area is extracted by making successive cuts 30 feet wide through the pillar. The conveyor is shortened as the work retreats, and the conveyor pans that are not needed between the outby crosscut and the aulageway are stored in this uncompleted crosscut. A line of breaker osts is placed 3 feet inside this opening to protect this equipment from aves. When extraction from the pillar is completed, the conveyor unit is oved to the next outby room neck, and this room is developed. When the ace of the room connects into the crosscut from the inby room, the con-eyor equipment previously stored in this opening in the retreat of the nby room is taken into this new room as it is needed to advance the con-eyor line. The advantage of this system is that only about half the ength of the pan line needs be removed to the haulageway on the retreat rom the room and pillar. (Refer to fig. 5-F.)

The loading equipment comprises 10 conveyors, but during the period overed in this discussion an average of four units were used per shift. e crew of a room conveyor unit comprises the following:

1 cutting-machine man
1 cutting-machine man helper
1 ratchet man
1 face man
1 car trimmer
5

If two room conveyors are working on an entry, a motorman is used to shift cars for the two units. When only one conveyor unit is working, the car trimmer shifts and places cars with an electric locomotive.

An entry crew comprises the following:

	Men
1 unit in the air course using	2
1 unit in the haulageway using	2
1 car trimmer for the two units	1
	5

The coal from the air course or upper heading is transported by the shaking conveyor to a cross conveyor placed in a crosscut and is discharged into the car on the haulage heading. The haulageway unit discharges directly into the car. As a rule, the headings are advanced approximately 32 pans (416 feet) before moving up. This is approximately 100 feet beyond the crosscut in which the cross conveyor is erected. The time required to move and erect pans in an entry is approximately 6 man-shifts and to move and erect a room unit averages approximately 12 man-shifts.

Haulage on entries is by electrically operated trolley-type locomotives to the slope. Entry trips comprise 12 cars that have a capacity of 3,300 pounds. From the entry partings or sidetracks, the cars are hoisted up the slope to an inside sidetrack by an electrically operated hoist. Slope trips comprise six cars at one slope and four at the other. An electric trolley-type locomotive transports the trips of 24 cars each from both inside partings to the tipple.

Power, which is 2,300-volt, 60-cycle, 3-phase, alternating-current, is purchased from a public utility company. This is converted by motor generator sets to 250-volt direct current for use on mining machines, drills, blowers, pumps, and locomotives.

The following labor is employed in a 24-hour period:

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	No. men	Shifts	Units	Total
Underground:				
Conveyor crew, including gathering..	6.75	2	4	54
	Day	Night		
Other underground employees:				
Hoisting engineers.............	2	2		4
Trackmen.......................	2			2
Slopemen.......................	4			4
Ventilation....................	1	1		2
Total other underground employees......................				12
Total underground employees.........				66
Surface employees:				
Motorman............................	1			1
Brakeman............................	1			1
Shop................................	4			4
Tipple..............................	16			16
Supervision.........................				2
Total surface employees.............				24
Grand total............................				90

Summary

Mechanization, percent..	100
Average daily production from mechanized units, tons............	743
Number conveyor units (average operated during period)..........	4
Number conveyor unit shifts per day.............................	8
Average number of men per unit per shift........................	6.75
Man-shifts per day on mechanized units..........................	54
Average tons per day per man on mechanized units................	13.75
Total number of employees underground...........................	66
Average tons per day per man underground........................	11.25
Total number of employees.......................................	90
Average tons per day per man employed...........................	8.24

Mine No. 22

This operation is mining coal from a bed that ranges from 38 inches to 4 inches in thickness under an average cover of 175 feet.

A section through the coal bed on this property at a representative oint would show, from top to bottom, 10 inches of bone, 4 inches of rash, 0 inches of coal, 4 inches of clay, 8 inches of coal, and then an irregular hale bottom. However, throughout the whole region in which this mine is ituated, the bed, lying comparatively level, is frequented by rolls and aults, which make a variation of the common mining practices necessary.

Entry into the coal bed is through a 400-foot 20° slope. A main haulageway leads from the bottom of the slope to all section entries. Panel room-and-pillar method is followed throughout the mine. (Refer to fig. 6.) Panel headings usually are driven 15 to 18 feet wide for 250 feet at one setting of the conveyor, and then as the conveyor is shortened room necks are driven on 50-foot centers in either right- or left-hand ribs. The roof of all haulage headings is brushed to allow 5-1/2 feet clearance above the rail, the rock being gobbed on one side of the heading.

Rooms are driven 24 feet wide and 225 to 250 feet long without crosscuts, since ventilation is provided at the face by means of tubing leading from an auxiliary fan.

The coal is undercut by a shortwall machine having a 6-foot cutter bar, and the cuttings are gobbed because the irregularity of the bottom generally makes it necessary to cut both rock and coal together. After cutting, holes are drilled in the face with an electrically operated auger-type drill. One or two sticks of permissible explosive are used in each hole, and an average of 6.54 tons of coal per pound of powder is obtained. The conveyor crew comprise four or five men who cut, drill, shoot, timber, and load. The cutting-machine man also is the car trimmer at the loading head on the heading. The five conveyor units are in five separated panels to prevent loss of tonnage from more than one unit when a panel is driven into a roll of fault.

Pillars are recovered on the retreat from the room by first cutting through to the next room, then leaving a small fender for protection, and cutting through again. About 85-percent recovery of coal is obtained.

A row of timber is carried on each side of the conveyor. The posts are on 5-foot centers and nearly all are recovered for use again. Average amount of timber used per ton of coal is 1 lineal foot.

Supplies are dragged to the face of the rooms by hand, since it is impossible to reverse the conveyor after it has been worn; but, on retreat, recovered timber and conveyor sections are transported to the heading by the conveyor itself.

Mine cars having a capacity of 1.3 tons usually are hauled by electric trolley-type locomotives in trips of 12 or 24 cars, depending upon grades to the sidetracks at the slope bottom. The average total daily tonnage is 728 tons, of which 465 tons (64 percent) is loaded mechanically. Loading is conducted on two shifts and the tipple operates an average of 1-1/2 shifts per day. The labor at this mine for 24 hours is:

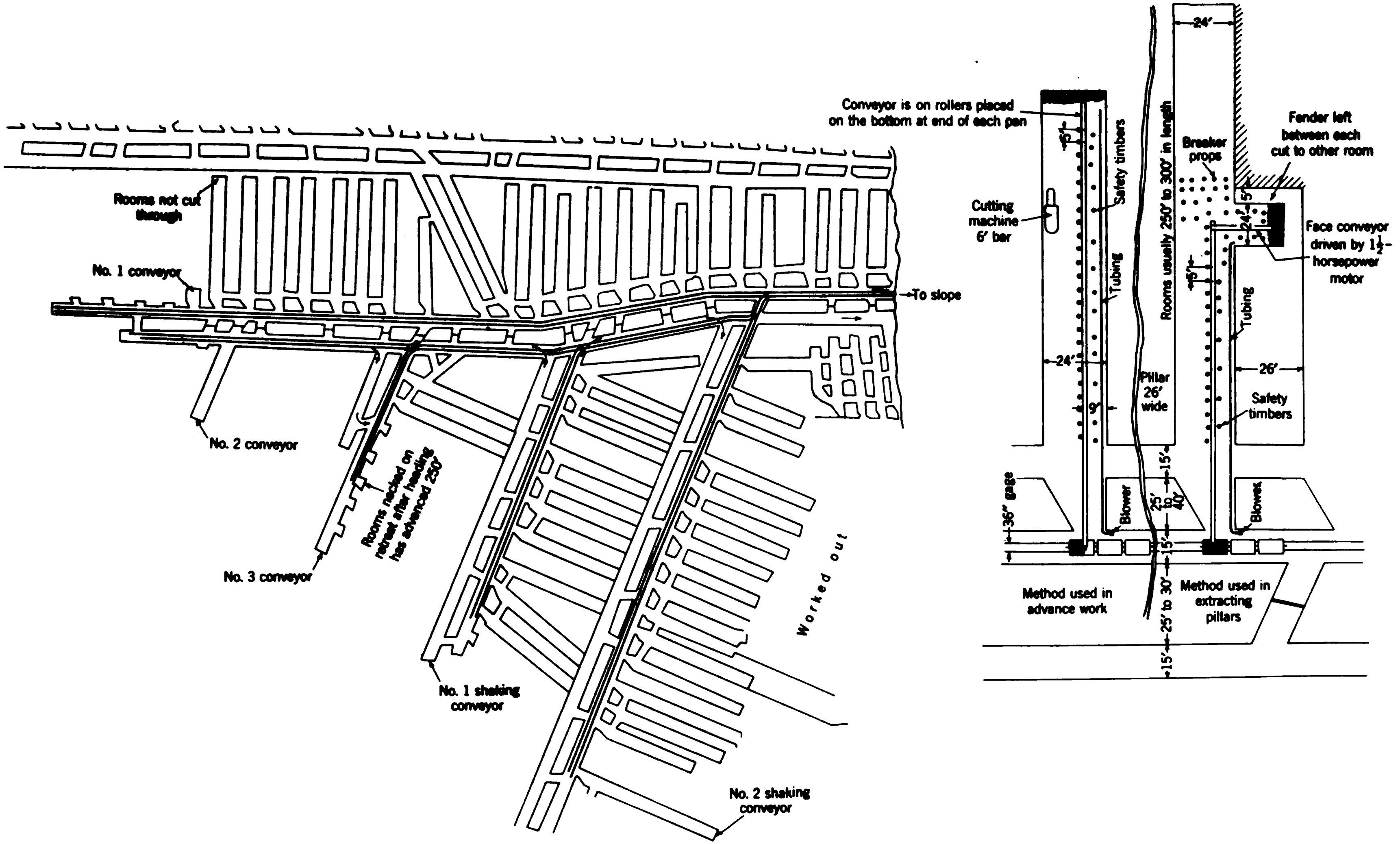
Rooms not cut through
No. 1 conveyor
No. 2 conveyor
No. 3 conveyor
Rooms necked on retreat after heading has advanced 250'
No. 1 shaking conveyor
No. 2 shaking conveyor
Worked out
To slope
Conveyor is on rollers placed on the bottom at end of each pan
Cutting machine 6' bar
Safety timbers
Tubing
24'
5'
9'
Pillar 26' wide
Rooms usually 250' to 300' in length
Breaker props
Fender left between each cut to other room
Face conveyor driven by 1½-horsepower motor
24'
5'
26'
Safety timbers
Tubing
Blower
Blower
36" gage
15'
25' to 40'
15'
25' to 30'
15'
Method used in advance work
Method used in extracting pillars

Figure 6.-Mining method at mine No. 22

Original from THE OHIO STATE UNIVERSITY

	Units	First shift	Second shift	Third shift	Total
Underground labor:					
Conveyors (shaking and chain)....	5	24	24	-	48
Motors........................	2	4	4	-	8
Total men directly chargeable to mechanized					56
Other underground employees:					
Rockmen........................		4	-	-	4
Pipeman........................		1	-	-	1
Roadman........................		1	-	-	1
Moving conveyors................		-	-	3	3
Supervision....................		1	1	-	2
Underground men chargeable to mechanization					67
Outside labor:					
Tipple:					
Shifter......................		1	1/2	-	
Hoist........................		1	1	-	
Picker.......................		1	1/2	-	
Dumper.......................		3	1	-	
Headman......................		1	1/2	-	
Total........................					10-1/2
Shop:					
Car repairman................		1	-	-	
Blacksmith...................		1	-	-	
Foreman......................		1	-	-	
Chief electrician............		1	-	-	
Helpers......................		3	1	-	
Total........................					8
Total outside labor..............					18-1/2
Total outside labor chargeable to mechanization (64 percent of total)................................					12
Total labor chargeable to mechanization.......................					79

Summary

Mechanization of mine, percent..................................	64
Average daily production for mechanized units, tons.............	465
Number of conveyors operated....................................	5
Number of conveyor shifts per day...............................	10
Average number of men per unit per shift........................	5.6
Man-shifts per day on mechanized units..........................	56
Average tons per day per man on mechanized units................	8.3
Total employees underground chargeable to mechanization.........	67
Average tons per day per man underground........................	6.94
Total employees, surface and underground, chargeable to mechanization..	79
Average tons per day per man employed on tonnage from mechanized units..	5.89

Mine No. 23

The coal bed at this operation lies comparatively level and ranges in thickness from 37 to 42 inches of workable height. The coal contains bony in the bottom and sometimes near the top in thicker sections of the bed. The roof is firm and there is very little draw slate.

Mining Methods

The mine is developed from a drift that enters the coal at the outcrop. The main entry consists of headings on 60-foot centers with crosscuts on 100-foot centers. Panel entries comprise two headings driven on 60-foot centers to the end of the panel section. The rooms are necked on 50-foot centers 14 feet wide as the heading is advanced. All haulageways are brushed to allow 5 feet 6 inches height above the rail. Rooms extend 300 feet from the entry and are driven 25 feet wide.

Scraper

A method of operating a scraper-loader simplifies the driving of headings where brushing is required. One hundred feet is opened 13 feet wide in the coal. During this operation the scraper transports the coal onto a steel runway that extends above a trip of six cars. This runway comprises sectional pans with openings above each car. The openings are graduated in size so that the pan nearest the face has the smallest openings. These graduated openings tend to distribute the scraper load more evenly over the trip. The steel runway is divided into sections or pans, and the legs that support the runway can be telescoped so that when it is necessary to move the pans can be lowered onto a trip of cars and hauled to a new location. The scraper hoist is a track-mounted unit and can be moved under its own power. The scraper operates at a speed of 250 feet per minute while loading. The design of this unit is described under mine No. 25.

A scraper crew usually comprises a hoist operator and a face man.

Mobile Conveyor

The mobile conveyor was first started at this mine in 1936. It is designed as a sectional unit that can be lengthened or shortened to suit requirements of local working conditions. The units at this mine ran on a 6-foot 5-1/2-inch-gage track using 20-pound rail. Adjustable sideboards allow the height of the conveyor to be adjusted to the coal height. The section of the sideboard nearest the face is hinged to facilitate loading. The end of the conveyor nearest the face is designated the rear and the end toward the heading is designated the front of the conveyor. Chain-driven flights extend across the bottom and drag the coal from the rear to the front of the conveyor. The coal is loaded by hand into the rear of the unit. When the rear section of the conveyor is filled, the coal is moved forward by the flights to provide space for further loading at the

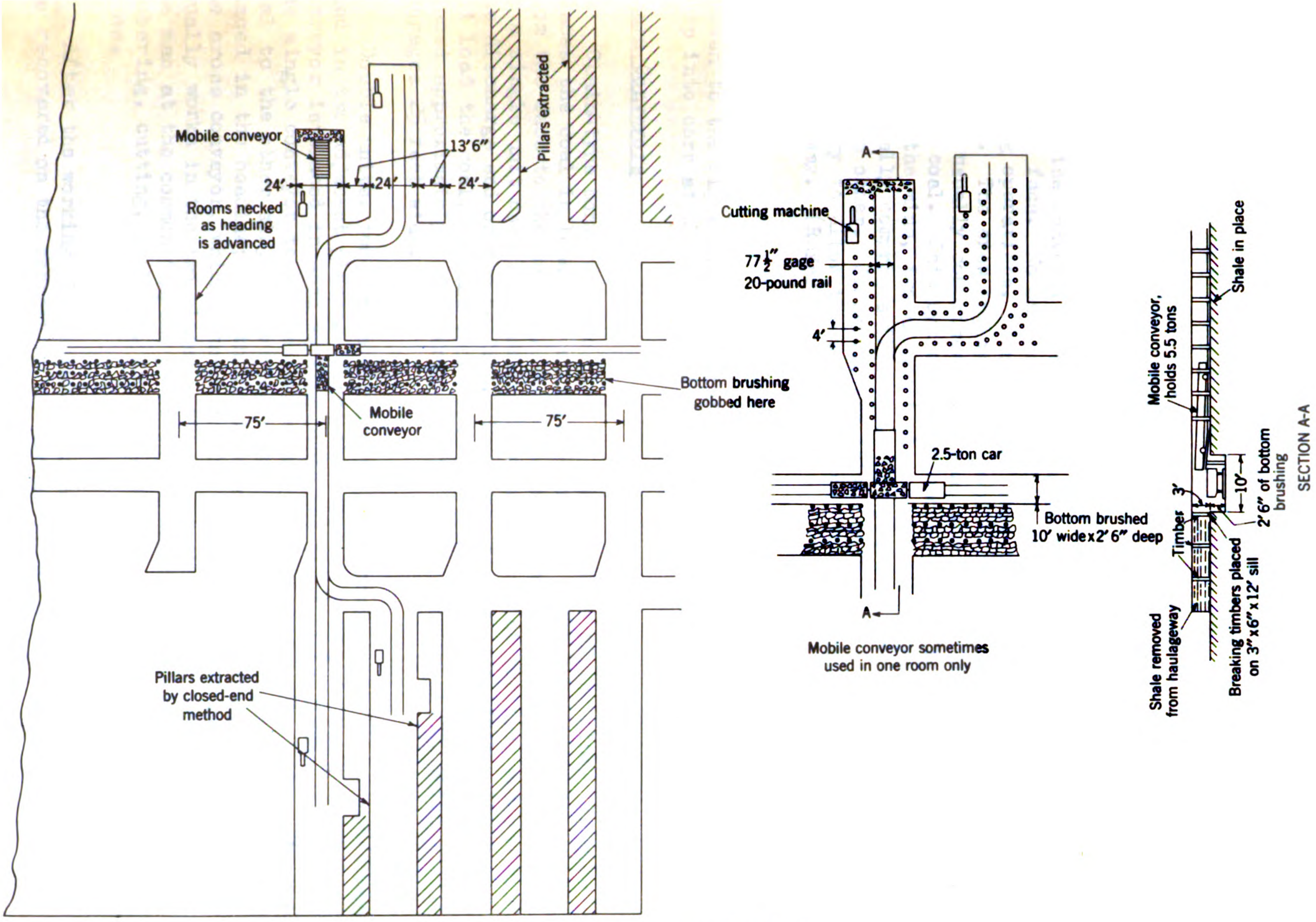
Mobile conveyor
13′6″
24′
24′
24′
Pillars extracted
Rooms necked as heading is advanced
75′
Mobile conveyor
75′
Bottom brushing gobbed here
Pillars extracted by closed-end method
A
Cutting machine
77½″ gage
20-pound rail
4′
2.5-ton car
Bottom brushed 10′ wide x 2′6″ deep
A
Mobile conveyor sometimes used in one room only
Shale in place
Mobile conveyor, holds 5.5 tons
10′
3′
2′6″ of bottom brushing
Timber
Shale removed from haulageway
Breaking timbers placed on 3″x6″x12′ sill
SECTION A-A

Figure 7.- Mining method at mine No. 23

end of the unit nearest the face. This operation is continued until the full length of the conveyor is filled. When the conveyor, which has an average capacity of 5-1/2 tons, is loaded, it is pulled to the dumping point by a 7/16-inch steel cable. One end of this cable is attached to a drum that is mounted on the conveyor and the other end is anchored at the dumping point. The coal is dumped by moving the flights forward. The conveyor is returned to the face by a similar arrangement of another drum and rope, except that one end of the rope is fixed at the face. One or two men ride the conveyor to the dumping point, dump the coal, and then return to the face. No one is required to stay on the entry during conveyor-loading operations. Conveyors of this type are used in both room and headings. The crew employed on a mobile unit of this type working a single place usually comprises three men, who timber, cut, drill, shoot, and load the coal. This cycle is continuous. (See fig. 7.) In some sections of the mine, two adjacent places are worked with one mobile unit. The crew usually comprises five men. One place is prepared while coal is loaded in the other. Crosscuts are driven between rooms about 40 feet from the entry to allow the unit to travel to the next room without going on a haulageway. (Refer to fig. 7.)

Two units from adjoining places may both load on a cross conveyor that dumps directly into cars. In some sections of the mine rooms are driven to the right and to the left off the entry and two mobile conveyors dump into cars at the same point on the haulageway.

Chain Conveyors

Chain-type conveyors are used in some sections of the mine. In some places the coal is loaded on a single conveyor, which transports the coal from the face to the heading, where it is discharged into cars. The crew on a single unit usually comprises four men, three at the face and one at the discharge end on the heading. These men timber, cut, drill, shoot, and load the coal, and all operations are continuous. The conveyor is placed approximately 7 feet from the rib of the working place, which averages 25 feet wide.

Double units, two single conveyors, and a cross conveyor are sometimes used in two adjacent places. Where this type of set-up is used, a single conveyor is placed in each working place and the coal is discharged from one single conveyor to a cross conveyor. The cross conveyor transports the coal to the other single conveyor, which discharges the coal into cars placed in the heading; or both single conveyors may discharge the coal to the cross conveyor, which transports the coal to cars. A five-man crew usually works in the two places - two men at the face of each place and ne man at the common dumping point on the heading. The mining cycle of imbering, cutting, drilling, shooting, and loading is continuous in each lace.

After the working places have been advanced to their limit, pillars re recovered on the retreat by the closed-end or pocket method.

Usually, four rows of timber are set in a working place - one on each side of the conveyor and one row about 4 feet from the ribs on approximately 4-foot centers. An average of 5.25 tons is produced per prop.

All holes are drilled in both coal and rock with electrically operated auger-type drills. The holes in the coal are charged with permissible explosive and fired electrically. An average of 10.25 tons of coal is produced per pound of explosive.

Brushing holes are charged with either 40- or 60-percent dynamite and fired electrically.

Mine cars are 12 feet long, 3 feet high, and have a capacity of approximately 2 tons (1.65 tons average). These cars are made up into trips of 6 to 12 and hauled from the various loading units to a common sidetrack by gathering locomotives. From these sidetracks the cars are transported to the tipple by a trolley-type electric locomotive.

Average number of men employed in 24 hours, chargeable to mechanized production, is as follows:

	Units	First shift	Second shift	Third shift	Total	Actual man-days worked
Underground labor:						
Mechanical loading units:						
Chain conveyors..........	9	28	30	28	86	76
Mobile conveyors.........	2	10	10	-	20	49
	4	12	12	12	36	
Scrapers.................	1	2	2	2	[1]6	6
Employees chargeable to mechanical units.............		52	54	42	148	131
Other underground employees:						
Trackmen....................		4	-	-	4	
Road cleaners...............		-	2	-	2	
Rockmen.....................		7	-	-	7	
Timberman...................		1	-	-	1	
Haulage.....................		10	8	5	23	
Maintenance.................		7	2	2	11	
Supervision.................		4	2	2	8	
		33	14	9	56	
Total other employees chargeable to mechanized production					[2]34	34
Total underground employees chargeable to mechanized production....................................					182	165
Surface employees:						
Tipple......................		12	12	-	24	
Shop........................		3	-	-	3	
Yard........................		2	-	-	2	
Lampman.....................		1	-	-	1	
Watchman....................		-	1	-	1	
Clerk.......................		1	-	-	1	
		19	13		32	
Total surface employees chargeable to mechanized production						[2]19
Total employees, underground and surface, chargeable to mechanized production..................................					201	184

[1] Works approximately 26 percent loading coal and 74 percent loading rock.
[2] Number of employees prorated to mechanized and hand loading.

Summary

		Actual man-days worked
Percent of mine mechanized	60	
Average daily production during period from mechanized units, tons	1,279	
Conveyors - 1,263		
Scraper - 16 (working on rock 74 percent of time)		
1,279		
Average number of mechanical units operated during period:		
Scrapers	1	
Chain conveyors	9	
Double units - 2		
Single units - 5		
Mobile conveyors	6	
Average number of loading shifts per day:		
Scrapers	[3] 3	
Chain conveyors	21	
Double units - 6		
Single units - 15		
Mobile conveyors	14	
Average number of men per unit per shift:		
Scraper[3]	2	
Chain conveyors:		
Double units	6	
Single units	4	
Mobile conveyors working two rooms	5	
Mobile conveyors working one room	3	
Man-shifts per day on mechanized units	148	131
Average tons per day per man on mechanized units:		
Scraper (coal)[3]		10.4
Chain conveyors		10.02
Mobile conveyor		10.03
All units (includes scraper time loading rock)		9.76
Total employees underground chargeable to mechanization	182	165
Average tons per man underground on mechanization		7.77
Total employees, surface and underground, chargeable to mechanization	201	184
Average tons per man per day chargeable to mechanization (underground and surface)		6.95

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[3] During this performance study, scraper was loading rock 74 percent of time, and coal 26 percent of time.

Mine No. 24

This operation comprises three openings designated in this description as mines A, B, and C. The production from these three openings is transported to a common tipple. The thickness of the coal bed averages 42 inches and there is usually a bone parting near the bottom of the bed. The strata immediately above the bed are variable in character, ranging from sandstone, which requires little support in mine A, to a tender shale in mine C, where crossbars are needed for safe support. The bottom is sandy shale.

Mining Methods at Mines A and B

The plans of these mines comprise main entries with four parallel headings on 70-foot centers driven 15 feet wide. Panel entries, comprising two headings on 60-foot centers 15 feet wide, are driven off the main headings on approximately 375-foot centers. Rooms are turned off the panel headings on 45- to 60-foot centers 18 feet wide and approximately 300 feet long. The operations at present comprise the recovery of barrier pillars, stump pillars, and chain pillars chiefly with conveyors in workings previously mined by hand methods.

Eighty percent of the production from mine A and 100 percent from mine B is loaded mechanically by means of conveyors. The conveyors that are the chain type are set up in a number of different systems to recover the coal from pillars in old workings. The most common system is the single conveyor that is placed along the center line of the working place and transports the coal from the face to the mine cars. This conveyor may extend 450 feet and is operated at a speed of 60 feet per minute by a 10-horsepower motor. Coal is loaded by hand on the conveyor by three men at the face. Another man spots the cars on the heading with a 5-horsepower slow-speed hoist. The mining cycle of timbering, cutting, drilling, shooting, and loading is continuous.

A double unit comprises three conveyors, two room conveyors in adjacent working places, and a cross conveyor. The cross conveyor transports the coal from the room conveyors to mine cars or from one room conveyor to the other that discharges the coal into mine cars in the heading. Three men are employed in each working place, with one other man on the heading to spot cars, a total of seven men on the double conveyor unit. The mining cycle is the same as with the single unit.

Face conveyors are used where the face of the working place is not adjacent to the main conveyor. The face conveyor, which is usually short, is driven by a 5-horsepower motor and is set at right angles to the main conveyor.

Application of conveyor mining to the recovery of barrier pillars between rooms and main entries is demonstrated at this mine. Ordinarily barrier pillars would be removed from the adjacent air course or heading, but usually these openings in the coal are filled with falls of rock.

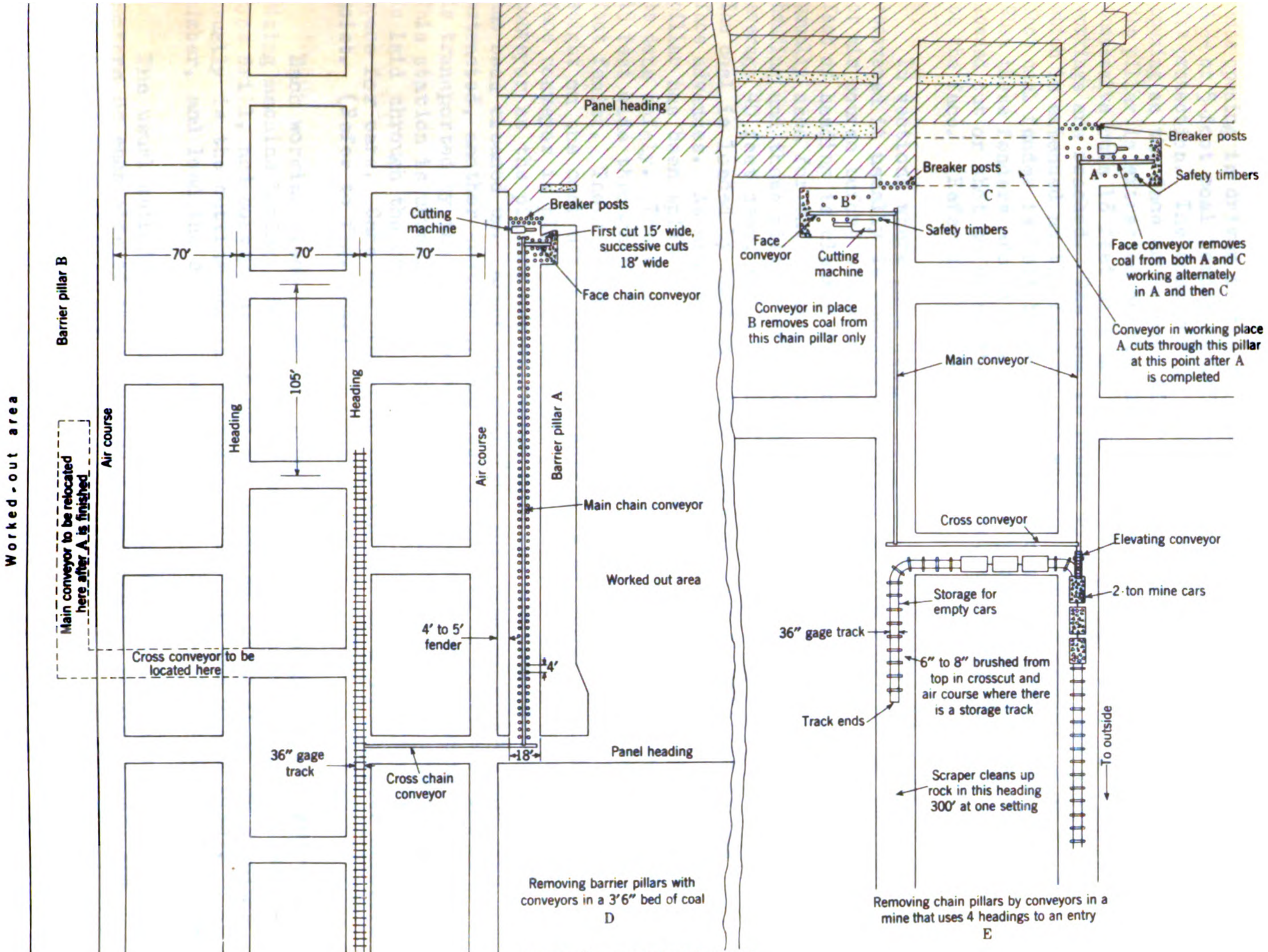

Worked-out area
Barrier pillar B
Main conveyor to be relocated here after A is finished
Air course
70′
70′
70′
Heading
105′
Heading
Cross conveyor to be located here
36″ gage track
Cross chain conveyor
Air course
4′ to 5′ fender
Cutting machine
Breaker posts
First cut 15′ wide, successive cuts 18′ wide
Face chain conveyor
Main chain conveyor
Barrier pillar A
4′
18′
Panel heading
Worked out area
Panel heading
Removing barrier pillars with conveyors in a 3′6″ bed of coal
D
Face conveyor
Cutting machine
B
Safety timbers
Breaker posts
C
Conveyor in place B removes coal from this chain pillar only
Main conveyor
Cross conveyor
36″ gage track
Storage for empty cars
6″ to 8″ brushed from top in crosscut and air course where there is a storage track
Track ends
Scraper cleans up rock in this heading 300′ at one setting
A
Breaker posts
Safety timbers
Face conveyor removes coal from both A and C working alternately in A and then C
Conveyor in working place A cuts through this pillar at this point after A is completed
Elevating conveyor
2-ton mine cars
To outside
Removing chain pillars by conveyors in a mine that uses 4 headings to an entry
E

Figure 8.–Mining method at mine No. 24

To obviate the dead work of cleaning up these rock falls, an 18-foot wide opening is driven in the barrier pillar parallel to the main heading. A 4- or 5-foot coal fender is left between this opening and the heading for protection. The conveyor is erected along the center line of the opening as the face advances. After the opening reaches a panel entry, the pillar is extracted on the retreat by the closed-end or pocket method. Successive cuts 18 feet wide are made into the pillar until the old workings are reached. The coal is loaded by hand onto a face conveyor, which is extended as the face of the working place advances. A 4- to 5-foot coal fender is left between successive openings through the pillar. When those fenders are no longer needed for protection they are either loaded out or shot to allow the roof to cave, thus relieving the weight on the face. (Refer to fig. 8-D.)

In sections where room stumps and chain pillars in old workings are recovered it usually is necessary to clean up rock falls in the heading or air course before the stumps and pillars are extracted. Generally, 300 feet of heading is cleaned from one setting of a scraper-loader, which is usually used for this kind of work. A main conveyor is erected in the heading and these pillars are recovered on the retreat. The room stumps average 40 feet deep, and a cut 15 feet wide is made through the pillar. The coal is loaded by hand on a face conveyor that is extended as the face advances. As many of the ribs of the pillar that remain after the pillar has been split by this opening are recovered on the retreat as can be done safely. The chain pillar is extracted by making successive cuts 15 feet wide through the pillar, the cuts being separated by a 4- to 5-foot fender. These fenders are recovered or shot down to relieve the weight on the coal after their protection is no longer required. The face conveyor is placed in alternate positions on each side of the main conveyor as the pillars are extracted from the 300 feet of heading that has been cleaned up. After the coal from this area of pillars has been extracted, another section of 300 feet of heading is prepared. The coal is transported by the main conveyor to cars placed at a loading station. This station is usually at a crosscut between two headings, and the track is laid through the crosscut into the other heading to provide storage space for cars. Cars are placed at the conveyor by a 5-horsepower electric hoist. (Refer to fig. 8-E.)

Each working place in all of these mines is equipped with a shortwall mining machine having a 6-foot cutter bar, an electrically operated auger-type drill, and conveyors. The man who operates the hoist on the headings usually is the cutting-machine operator. The other men drill, blast, timber, and load the coal on the conveyors. The operations are continuous.

The usual method of timbering is to set one row of posts on 4-foot centers on each side of the conveyors 4 feet apart. Safety timbers are set at the face as required.

Mine cars are gathered by two gathering locomotives, which haul them to the sidetrack. The coal is hauled to the outside by a 15-ton locomotive. Mine cars have a capacity of 1.4 tons.

All repair work except that necessary on haulage motors or conveyor pans is done in a completely equipped underground repair shop.

Mining Methods at Mine C

The coal bed at this location is under only 30 to 60 feet of cover, with the strata immediately above the 44-inch coal bed comprising 6 inches of bone and 6 inches of draw slate. This bone and draw slate make a tender roof that requires special methods of timbering.

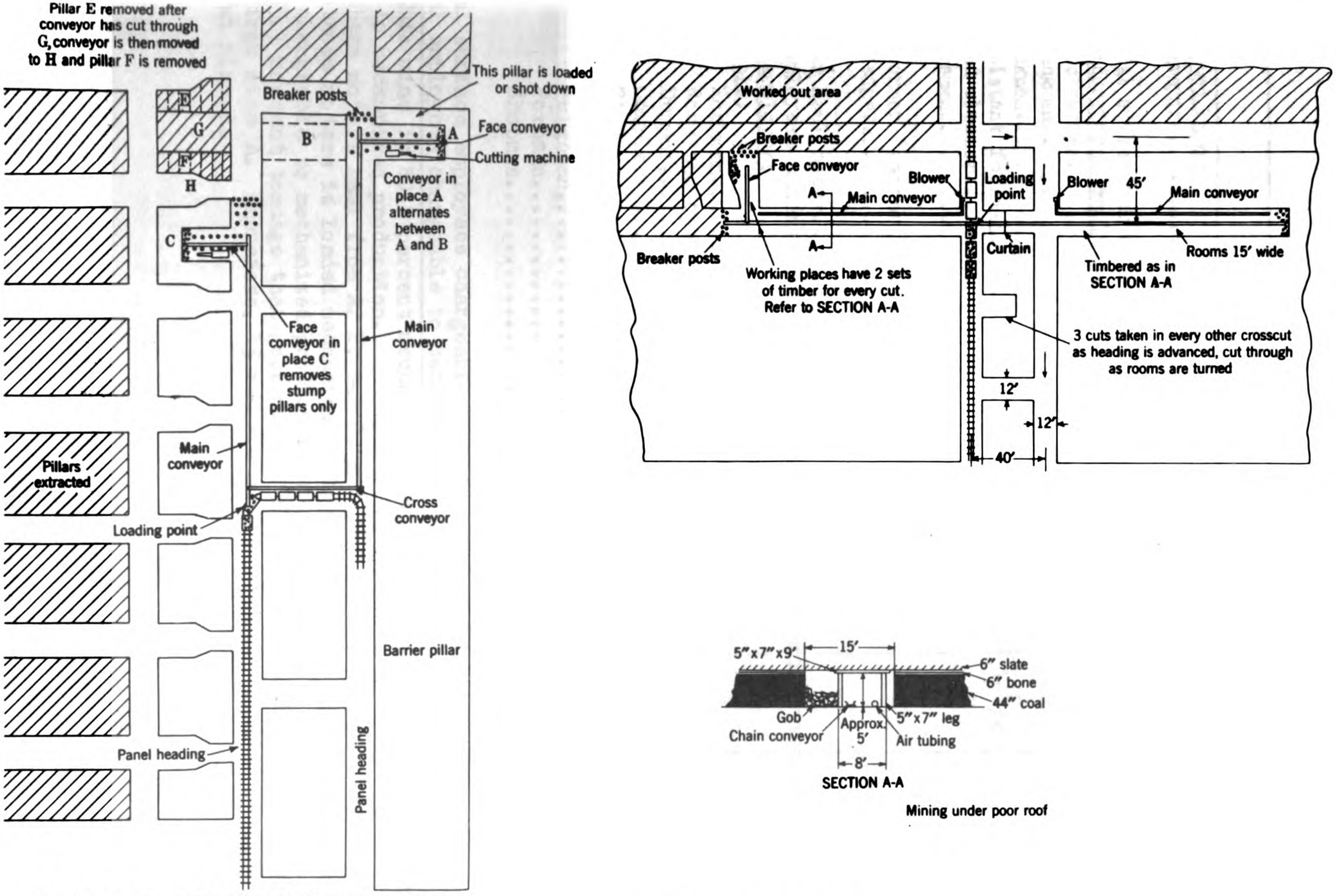
Panel headings in this mine are driven in pairs 13 feet wide on 40-foot centers. Rooms 16 feet wide are turned to the right and to the left on 45-foot centers, one off the haulageway and the opposite room off the air course. Three cuts are made in every other crosscut in the chain pillar between the heading and air course. The alternate crosscut is cut through the pillar 12 feet wide. The bottom of the haulageways is brushed to a depth of approximately 18 inches.

An average of 511 tons per day is loaded by hand on one double shaking-conveyor unit and three single-chain conveyors. The arrangement of the conveyors is similar to that in mines A and B but the method of timbering differs. The roof is so tender in many places that three-piece sets of timber are placed on 3-foot centers along the entire length of rooms and headings.

The timber sets in rooms comprise two legs cut long enough to hold a 4-inch by 8-inch by 9-foot or 5-inch by 7-inch by 10-foot cross bar tight against the roof. The cross bar is supported 6 inches from each end by the two legs. One leg is set approximately 2 feet from the right-hand rib and gob is placed between the other leg of the set and the left-hand rib. Cross bars of heading sets usually are 6 inches by 8 inches by 10 feet long. (See fig. 9.)

Three gathering locomotives place the empties convenient to the conveyors, where the cars are spotted for loading with small electric slow-speed hoists. Loaded trips are transported to sidetracks and a main-line locomotive hauls the trips to the tipple.

The following labor is employed during a 24-hour period at mine A:


Pillar E removed after conveyor has cut through G, conveyor is then moved to H and pillar F is removed
E
G
F
H
C
B
A
Breaker posts
This pillar is loaded or shot down
Face conveyor
Cutting machine
Conveyor in place A alternates between A and B
Face conveyor in place C removes stump pillars only
Main conveyor
Main conveyor
Pillars extracted
Loading point
Cross conveyor
Barrier pillar
Panel heading
Panel heading
Worked out area
Breaker posts
Face conveyor
Blower
Loading point
Blower
45′
Main conveyor
Main conveyor
A
A
Breaker posts
Working places have 2 sets of timber for every cut. Refer to SECTION A-A
Curtain
Timbered as in SECTION A-A
Rooms 15′ wide
3 cuts taken in every other crosscut as heading is advanced, cut through as rooms are turned
12′
12′
40′
5″x7″x9′
15′
6″ slate
6″ bone
44″ coal
Gob
Chain conveyor
Approx. 5′
5″x7″ leg
Air tubing
8′
SECTION A-A

Extracting room stumps, chain and barrier pillars along panel entries

Mining under poor roof

Figure 9.–Mining method at mine No. 24

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	Units	First shift	Second shift	Third shift	Total	
Underground labor:						
Conveyors	{4 (single)	16	16	16	48	
	2 (double)	14	14	14	42	
Total number men on conveyors						90
Other underground employees:						
Electrician		1	1	1	3	
Trackmen		4	-	-	4	
Rockmen		2	1	-	3	
Assistant foremen		2	1-1/2	1-1/2	5	
Road cleaner		-	-	1	1	
Foreman		1	-	-	1	
						17
Motormen (gathering)		2	2	-	4	
Spraggers		2	2	-	4	
					1/8	6
Main haul motor		2	2	-	2/4	1
otal employees underground chargeable to mechanized production						114
urface employees:						
Tipple:						
Rockman		-	1	-	1	
Rock-car operator		-	1	-	1	
Dumpers		2	1	-	3	
Couplers		2	1	-	3	
Pickers		5	3	-	8	
Car droppers		2	2	-	4	
Weighman		2	1	-	3	
Foreman		1	1	-	2	
Shopmen		9	2	-	11	
					3/36	
otal surface employees chargeable to mechanized production						13
otal employees chargeable to mechanized production						127

/ This mine is 80.2 percent mechanized. Six men on gathering are chargeable to mechanized production.

/ These motors haul from A, B, and C, and 35.7 percent of coal hauled by these motors is loaded mechanically in mine A. Therefore, one man is chargeable to mechanized production at mine A.

/ 35.7 percent tonnage that goes over tipple is mechanically loaded coal from mine A. Therefore, 13 men are chargeable to mechanized production at mine A.

Summary, Mine A

Percent of mine mechanized	80.2
Average daily mechanized production during period, tons	978
Number of conveyors operating during period {single - 4, double - 2}	8
Number of conveyor-shifts per day	24
Average number of men per unit per shift	3.75
Man-shifts per day on conveyors	90
Average tons per day per man on conveyors	10.87
Total employees underground chargeable to mechanized production	114
Average tons per day per man underground	8.57
Total employees, surface and underground	127
Average tons per day per man chargeable to mechanized production	7.70

The following labor is employed during a 24-hour period at mine B (100-percent mechanized):

	Units	First shift	Second shift	Third shift	Total
Underground labor:					
Double conveyor	1	5	5	5	15
Single conveyor	2	8	8	8	24
Total men on conveyors					
Other underground labor:					
Gathering locomotive	1	1	1	1	3
Rock men		2	2	2	6
Assistant foremen		1	1	1	3
Foreman		1	-	-	1
Repairman		1	-	-	1
Total other underground labor					
Total men underground chargeable to mechanized production					

Mine C - 51 Percent Mechanized

	Units	First shift	Second shift	Third shift	Total
Underground labor:					
Conveyor (chain)	3	12	12	12	36
Conveyor (shaker)	2	5	5	5	15
Total men on conveyors					
Other underground labor:					
Motormen		3	3	2	8
Brakemen		2	2	2	6
Tracklayer		1	-	-	1
Bratticeman		1	-	-	1
Assistant foremen		1	1-1/2	1-1/2	4
Foreman		1	-	-	1
Total underground men					4/21
Repairmen chargeable to mechanization					
Total men underground chargeable to mechanized production					

4/ 51 percent of production is from mechanized units; therefore, 11 men are directly chargeable to mechanization.

Summary, Mines B and C

(Mines B and C are combined, as C is considered a section of mine B.)

Percent of mine mechanized	62.9
Average daily mechanized production during period, tons	960
Number of conveyors operated during period - 1 double and 7 single	9
Number of conveyor-shifts per day	27
Average number of men per unit per shift	3.33
Man-shifts per day on conveyors	90
Average tons per day per man on conveyors	10.66
Total employees underground chargeable to mechanized production	118
Tons per day per man underground chargeable to mechanized production	8.13
Total employees on surface = [5]36	12
Total employees on surface and underground chargeable to mechanized production	130
Average tons per day per man employed chargeable to mechanized production	7.38

---

[5] 34.2 percent of tonnage passing over tipple is mechanically loaded coal from mines B and C; therefore, 12 men are chargeable to mechanized production from mines B and C.

Summary, Mine No. 24

(Mines A, B, and C Combined)

Percent of mines mechanized	70.6
Average daily production during period, tons	1,938
Number of conveyors operating during period	17
Number of conveyor-shifts per day	51
Average number of men per unit per shift	3.53
Man-shifts per day on mechanized units	180
Average tons per man on mechanized units	10.76
Total employees underground chargeable to mechanized production	232
Tons per day per man underground chargeable to mechanized production	8.35
Total employees, surface and underground, chargeable to mechanized production	257
Average tons per day per man employed chargeable to mechanized production	7.54

Mine No. 25

This mine is a new opening and virtually all work is the development of headings. Approximately 32 percent of the operation is mechanized.

The coal bed averages 42 inches thick, but where local rolls occur the thickness sometimes decreases to 18 inches. Usually there are 6 to 8 inches of bony above the coal. The roof and bottom are sandy shale.

Haulageways are driven 12 feet wide and the roof is brushed to approximately 6 feet above top of rail. Air courses usually are 18 to 20 feet wide and are not brushed.

The mechanical equipment used in driving development at the time the mine was visited consisted of two scraper-loaders and one mobile conveyor. Only the operation of these units will be described.

Scrapers

The loading equipment comprises a scraper-loader and an elevated runway that extends over a trip of six cars. (Refer to fig. 10.) This runway consists of sectional pans with openings above each car. The sizes of the openings are graduated so that the pan nearest the face has the smallest opening. These graduated openings tend to distribute the scraper load more evenly over the trip of cars. The scraper is used to load both coal and rock brushing. The rock is loaded into cars and is not gobbed. The headings are driven 12 feet wide and the coal is undercut with a shortwall cutting machine equipped with a 6-foot cutter bar. The faces are drilled with an electric auger-type drill and the holes are charged with permissible explosive and fired electrically. Usually the coal is extracted for a distance of 100 feet and then the roof is drilled with a jackhammer powered by compressed air from a portable air compressor. Holes are drilled at an angle of approximately 45° in a direction away from the face, and usually three holes are placed in a row across a 12-foot heading. The holes are charged with 1-1/2 sticks of 60-percent ammonia dynamite and fired electrically. When both rock and coal have been removed, the track and trolley line are extended. The improved entry scraper-loader, comprising hoist, sheaves, and runway, is moved ahead and operations are continued. The runway, which is supported by telescopic legs, is lowered to a trip of cars and transported ahead to the new position. Little timbering is required and safety props are set where necessary.

The crew working on the improved entry scraper-loader comprises two men, who cut, drill, shoot, and timber, load the coal and rock, lay the track, and move the equipment ahead on each advance. Where 80-pound track is used, one additional man is required during the track-laying operation. Trolley-wire extension and bonding are performed by the mine maintenance force.

Mobile Conveyor

The mobile conveyor is used in advancing the air course where no brushing is done. This conveyor is a sectional unit that is moved on a 6-foot 5-1/2-inch-gage track by two 7/16-inch steel cables, one attached to the face and the other at the dumping point. The cables are wound upon two electrically operated drums on the conveyor. The sections are 6 feet long and a conveyor usually comprises three sections, a total length of 18 feet. Chain-driven flights extend across the bottom of the conveyor and drag the coal from the end nearest the face to the front. The end

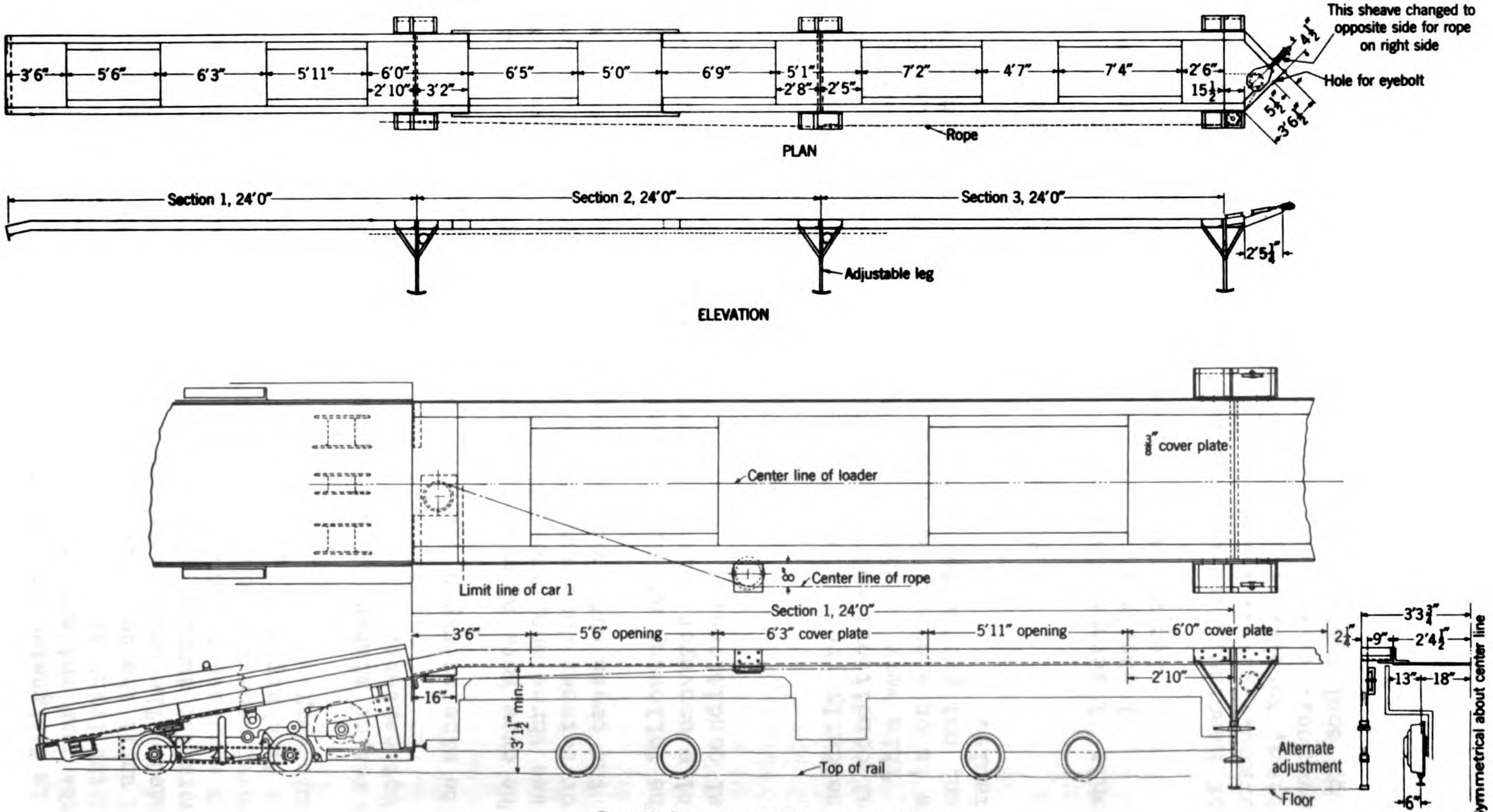

Figure 10.–Detail of scraper equipment at mine No. 25

toward the face is designated the rear and the end toward the discharge point is designated the front of the conveyor. The coal is loaded by hand into the rear end and, as the rear section is filled, the coal is dragged toward the front of the conveyor by the flights. This operation is continued until the conveyor, which has a capacity of approximately 6 tons, is loaded. The unit is then transported to the dumping point. In development work the dumping point usually is at a cross conveyor, which extends through a crosscut connecting the air course and the haulageway. The coal is removed from the mobile conveyor by moving flights forward, and the coal is discharged to the cross conveyor, which transports it to cars in the haulageway.

A row of timbers is set on each side of the track, generally spaced on 4-foot centers.

The mine averages 10.4 tons of raw coal per pound of explosive.

The crew working with the mobile conveyor in the air course usually comprises three men, who cut, drill, shoot, timber, load, and operate the conveyor between face and dumping point and spot cars at the discharge end of the cross conveyor in the haulageway by means of a slow-speed hoist.

The following are interesting records of performance of both scraper and mobile conveyor units employed in development work under varying physical conditions.

Performance Records

The daily production of coal from development headings varies with physical conditions and ranges from 48 to 70 tons per day from mechanized units. This work is not comparable with mines where entry and panel tonnage is on a normal operating basis. The classification of mine employees is given, but production per man has not been computed as daily tonnage is so variable.

Performance Data - No. 1 Period

quipment: 1 scraper-loader
1 shortwall cutting machine, 6-foot cutter bar
1 electric auger-type drill.

idth of heading, feet	12
ays worked	7
roduction, tons	226
eet advance	108
umber of coal cuts	21

Average geological section:

	Inches
Rock (36 yards), thickness	33
Bony	5
Coal	40

Performance Data - No. 1 Period - Continued

Classification of work	Man-hours		Percent of total	
Loading coal		154		52.5
Deadwork and yardage:				
Miscellaneous	6		2.0	
Rolls and clay veins	3		1.0	
Rib yardage (crosscuts)	9		3.1	
Total deadwork and yardage		18		6.1
Total in coal		172		58.7
Brushing:				
Move and set-up	15		5.12	
Maintenance	7		2.39	
Rock drilling	9		3.07	
Rock loading	60		20.48	
Tracklaying	23		7.85	
Trolley and bonding	7		2.39	
Total		121		41.3
Total coal and brushing		293		100.0

Summary

Coal	
Total coal produced during period, tons	226
Feet advance in heading	108
Man-days in coal	22
Advance per man-day, feet	4.9
Tons per coal-man-day	10.2
Total man-hours in coal, including rib coal	172
Man-hours per ton	0.7
Tons per man-hour	1.
Lineal feet per man-hour advance exclusive of rib yardage	0.6
Man-hours per foot of heading advance	1.5
Rock brushing	
Total feed of brushing	108
Total cars of rock	115
Man-days on rock	16
Advance per man-day, feet	6.7
Total man-hours, including drilling	121
Lineal feet per man-hour	0.9
Man-hours per foot	1.0
Man-hours per foot, coal and brushing (exclusive of crosscuts)	2.
Approximate pounds of 60 percent ammonia dynamite used for brushing	75
Approximate pounds per foot advance	0.
Feet of track laid	108
Number of ties used	55
Weight of rail used, pounds per yard	80
Trolley wire strung, feet	108
Track bonds used	7

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Performance Data - No. 2 Period

quipment: 1 scraper-loader
1 shortwall cutting machine, 6-foot cutter bar
1 electric auger type drill

idth of heading, feet..........	12
ays worked.....................	8
roduction, tons................	243
eet advance....................	111
umber of cuts..................	22

Average geological section:

	Inches
Rock.......	34
Bony.......	5
Coal.......	40

lassification of work	Man-hours		Percent of total time	
Loading coal.................		155		54.39
Deadwork and yardage:				
Rolls and clay veins...	2		0.70	
Rib yardage (crosscut).	9		3.16	
Total deadwork and yardage...............		11		3.86
Total in coal................		166		58.25
Brushing:				
Move and set-up........	13		4.56	
Maintenance............	7		2.46	
Rock drilling..........	10		3.51	
Load rock..............	51		17.89	
Tracklaying............	26		9.12	
Trolley and bonding....	12		4.21	
Total..................		119		41.75
Total, coal and brushing....		285		100.00

Summary

al:

Total coal produced during period, tons....................	243
Feet advanced in heading..................................	111
Man-days in coal..	22.1
Advance per man-day in coal, feet.........................	5.0
Tons per coal-day man.....................................	11.0
Total man-hours in coal, including rib coal...............	166
Man-hours per ton...	0.68
Tons per man-hour...	1.46
Lineal feet per man-hour, exclusive of rib yardage........	0.67
Man-hours per foot of heading advance.....................	1.50

shing:

Total feet of brushing....................................	111
Total cars of rock..	109
Man-days on rock..	15.6
Advance per man-day, feet.................................	7.1

Summary - Continued

Brushing - Continued:	
Total man-hours, including drilling	119
Lineal feet per man-hour	1.02
Man-hours per foot	0.98
Total man-hours per foot, coal and brushing, exclusive of crosscuts	2.48
Approximate pounds of 60 percent ammonia dynamite used for brushing	76
Approximate pounds per foot advance	0.68
Feet of track laid	111
Number of ties used	60
Weight of rail used, pounds per yard	80
Trolley wire strung, feet	111
Track bonds used	7

Performance Data - No. 3 Period

Equipment: 1 mobile conveyor.
1 shortwall cutting machine, 6-foot cutter bar.
1 electric auger-type drill.

Width of back heading, feet	20
Days worked	13
Production, tons	751
Feet advance	240
Number of cuts	39

	Inches
Average thickness of coal	42
Bony	5

Classification of work	Man-hours		Percent of total time	
Loading coal		504		95.6
Deadwork and yardage				
Miscellaneous	14		2.7	
Rolls and clay veins	9		1.7	
Total deadwork and yardage		23		4.4
Total		527		100.0

Summary

Man-days	72
Tons per coal-man-day	10.42
Total man-hours	527
Man-hours per ton	0.70
Tons per man-hour	1.43
Lineal feet per man-hour	0.46
Man-hours per foot	2.20

Number employed during a 24-hour period:

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	Units	First shift	Second shift	Third shift	Total	
Underground labor:						
Scrapers	2	4	4	4	12	
Mobile loaders	1	3	-	3	6	
Total men on mechanical units						18
Other underground labor:						
Trackmen		1	1	-	2	
Locomotive crew		2	2	2	6	
Maintenance		1	1	1	3	
Supervision		1	1	1	3	
Total other underground employees					[1] 14	4
Total underground employees chargeable to mechanized production						22
Total surface employees chargeable to mechanized production						1
Total employees chargeable to mechanized production						23

[1] 32 percent of production is from mechanized units; therefore, 4 of other underground employees are chargeable to mechanized production.

SUMMARY OF PERFORMANCE

Mining operations were conducted on more than one 7-hour shift in all the mines described. The advantages of loading coal mechanically on more than one shift have been stated in detail in Information Circular 7014,[5] but are repeated briefly.

A smaller capital charge per ton results when the daily output can be produced over two or more shifts by the same equipment.

All of the operations in the cycle of mining follow one another in a definite sequence and for optimum results should be continuous. Some State laws prohibit blasting with explosives during the working shift. Devices are used and improvements are being made in equipment that will make it possible to break down the coal safely while men are at work in the mine if proper precautions are taken to lay the dust by using water on cutter bars and to wet the face and working places thoroughly before blasting is done. All places should be properly rock-dusted.

The concentration of working places in a relatively small area lends itself to closer supervision. The success of any type of mechanization, not only with reference to output per man but also in regard to safety of operation, is in proportion to the amount of supervision.

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[5] Toenges, Albert L. and Anderson, Robert L., Work cited (footnote 4), pp. 47-48.

Multiple-shifting is a decided factor in rapid extraction from a given area and should result in greater recovery, a factor in conservation. Roof conditions are likely to cause less trouble when extraction is rapid, since the coal is removed before the full effects of roof action are operative.

As the working places are concentrated in a small area, the ventilation system is simplified and should be less costly than for the same tonnage from scattered areas. The cost of haulage operations and maintenance of track should also decrease.

The advisability of working a mine two or three shifts per day for obtaining optimum results is recognized, and this practice should be followed where possible. Although further study of the efficiency of the worker shows little variation on the different shifts, it is believed advisable at present to reserve the third or "graveyard" shift, or at least part of it, for maintenance of equipment, track extension, timbering, moving, and preparation of working places. Mechanical breakdowns usually result in loss of tonnage and increased costs. For safety of operation, however, the same supervision should be given on all shifts. This is important.

EXPLANATION OF GRAPHS

The graphs were prepared from data in both Part 1, Information Circular 7014, and the present report, Part 2. Although the number of mines is limited, the curves are interesting and show certain trends. Further investigations may develop variations.

Figure 11 is a curve determined by plotting the weighted average value of tons of coal per mobile-loader shift as the ordinates and the thickness of the coal bed as the abscissas. The curve shows the average rate of increase in tonnage per machine shift as the thickness of the bed increases. The data were taken from the 11 mines using mobile loaders described in Information Circular 7014 and this paper.

Point 115 tons and 108 inches, which is far below the average tons per machine for this thickness of coal, was not used in the determination of the curve as the loading equipment was obsolete at the time the mine was visited. Point 83 tons and 42 inches is below the weighted average curve because the transportation of the coal from the loading machine by conveyors is retarded at times by the occurrence of abnormal dips. Point 294 tons and 72 inches represents a mine in which the coal is transported from the mobile loading machine to a transfer station by tractor-trailer uni A rough time-study made at this mine showed that the mobile loading machines are loading coal 80 percent of the time while at the face of a working plac This percentage of working time represents high efficiency in operation of a loading machine. (Refer to mine 20.) Point 300 tons and 156 inches represents an operation that is mining in a coal bed 26 feet thick. Eleven feet of the bed is removed during first mining and the remaining 15 feet is extracted on second mining; thus, the average thickness moved during the two operations is 13 feet. The production per machine shift is below average because of a difficult transportation problem.

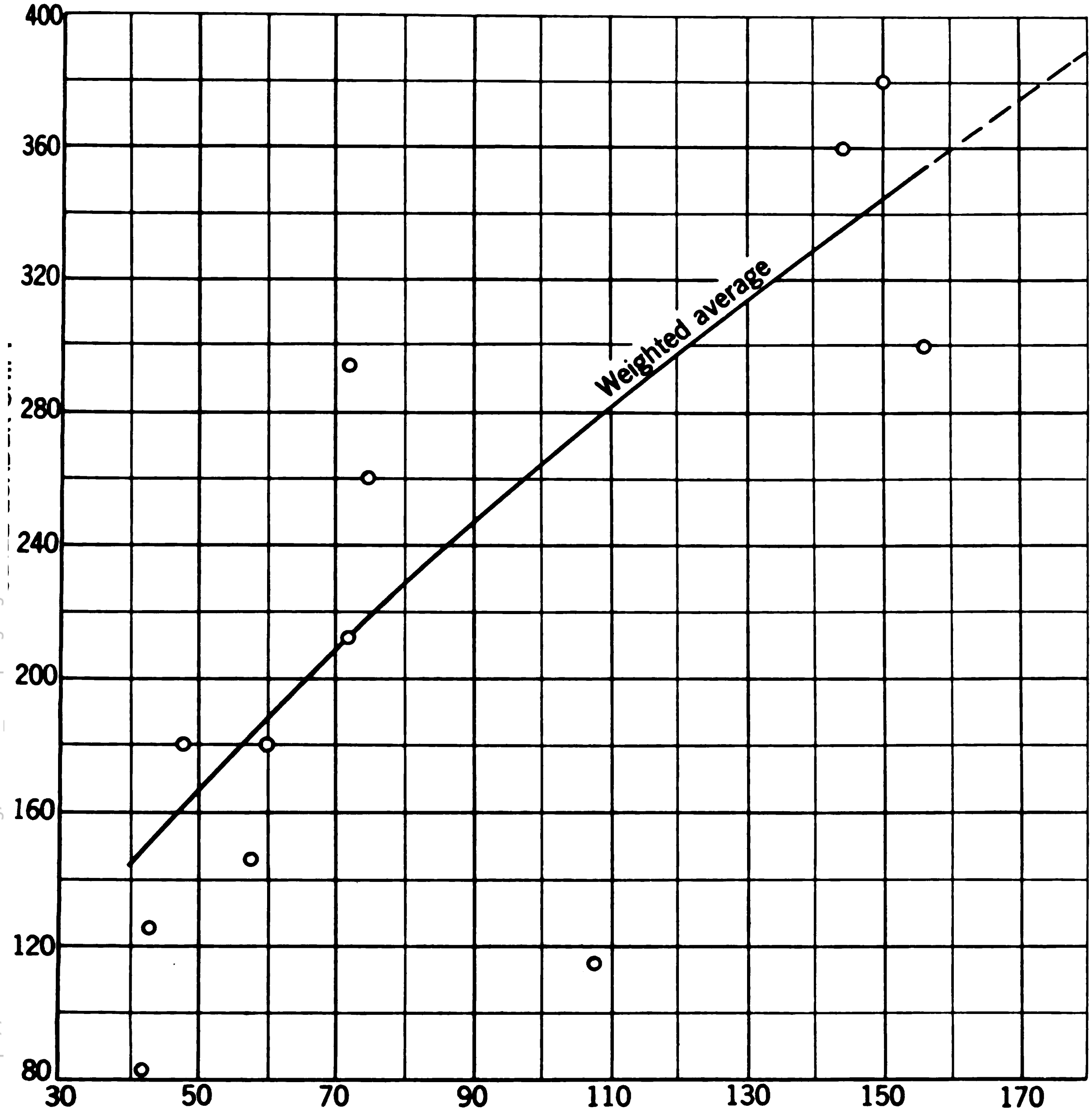

Figure 11.-Relation of tons per mobile loader shift to thickness of coal bed

performance, mobile loaders

	Mine		
	15	16	17
Description of mechanization:			
Cutting machines, type	Shortwall and track	Shortwall and track	Track-mounted
Loading machines, type	Power shovels and track-mounted mobile	Mobile loaders, crawler type	Mobile loaders, track-mounted
Machine loading	Loading into cars	Loading into cars	Loading into cars
Location of mine	Colorado	Utah	Utah
Percent of mine mechanized	[1] 65	100	100
Average daily production from mechanized units, tons	[1] 925	2,400	1,442
Thickness and dip of coal bed	9 feet - 8° to 12°	26 feet - 6°	12 feet - 7°
Number and hours of shift in mine	See text	2 - 7, see text	See text
Number and hours of shift in tipple	1 - 7 hours	1 - 7 hours	See text
Number of loading machines	8	5	2
Number of loading machine shifts per day	8	8	4
Average number of men per unit per shift	10	19	18
Man-shifts per day on mechanized units	80	152	72
Average tons per day per man on mechanized units	11.56	15.78	20.0
Total number of employees underground[2]	[3] 90	213	127
Average tons per day per man underground[2]	10.28	11.26	11.35
Total number of employees, surface and underground[2]	[3] 114	328	148
Average tons per day per man employed[2]	8.11	7.32	9.74
Average tons of coal produced per pound of explosive	5.80	3.9	3.74
Average tons of coal produced per prop	18.0	See text	See text
Total power consumed per ton of coal, kw-hr.	([4])	([4])	([4])
Estimated recovery, percent	80	40	([4])
Size of mine car, tons	1.8	4.1	3 and 6

(See footnotes on following page.)

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TABLE 1. - Summary of performance, mobile loaders - Continued

	Mine		
	18	19	20
Description of mechanization:			
Cutting machines, type	Track-mounted	Shortwall	Shortwall
Loading machines, type	Mobile loaders, crawler type	Mobile loaders, crawler type	Mobile loader, crawler type
Machine loading	Loading into cars	Loading into cars	Loading into trailers
Location of mine	Utah	Indiana	Indiana
Percent of mine mechanized	100	100	100
Average daily production from mechanized units, tons	1/ 1,520	1,080	1,176
Thickness and dip of coal bed	12-1/2 to 17 feet - 6°	4 feet - level	6 feet - level
Number and hours of shift in mine	See text	2 - 7 hours	2 - 7 hours
Number and hours of shift in tipple	See text	1 - 7 hours	1 - 7 hours
Number of loading machines	2	4	3
Number of loading machine shifts per day	4	6	4
Average number of men per unit per shift	16.25	12	9
Man-shifts per day on mechanized units	65	72	36
Average tons per day per man on mechanized units	23.35	15.0	32.66
Total number of employees underground2/	3/ 101	119	49
Average tons per day per man underground2/	15.04	9.07	24.0
Total number of employees, surface and underground2/	3/ 144	141	69
Average tons per day per man employed2/	10.55	7.65	17.04
Average tons of coal produced per pound of explosive	3.73	2.1	5.53
Average tons of coal produced per prop	See text	2.8	30.0
Total power consumed per ton of coal, kw-hr.	5/ 5.2	6.0	6.9
Estimated recovery, percent	4/ See text	(4/)	62
Size of mine car, tons	2.6 to 4.0 see text	2	5-ton tractor-trailer

1/ Tonnage from loading machines. 2/ Includes proportion of employees according to percent of mechanization. 3/ Men chargeable to tonnage from loading machines. 4/ Not available. 5/ Total power underground including mobile loaders and conveyors.

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Summary of performance, conveyors

	Mine			
	15	18	21	22
Description of mechanization:				
Cutting machines, type	Solid shooting	Shortwall	Shortwall	Shortwall
Conveyor, type	Chain face	Shaking	Shaking	Shaking-chain
Loading method	Hand loaded	Self-loading heads	Self-loading heads	Hand loaded
Location of mine	Colorado	Utah	Wyoming	Pennsylvania
Percent of mine mechanized	1/ 16	100	100	64
Average daily production from mechanized units, tons	1/215	1/230	743	465
Thickness and dip of coal bed	9 feet - 8°-12°	12-1/2 to 17 feet - 6°	7-1/2 feet - 13°	3-1/2 feet - level
Number and hours of shift in mine	See text	See text	2 - 7	2 - 7
Number and hours of shift in tipple	1 - 7	See text	1 - 7	10-1/2 hours
Number of conveyor units	1	2	4	5
Number of conveyor-unit shifts per day	2	4	8	10
Average number of men per unit per shift	13	5.5	6.75	5.6
Man-shifts per day on mechanized units	26	22	54	56
Average tons per day per man on mechanized units	8.26	10.54	13.75	8.3
Total number of employees underground2/	1/28	3/27	66	67
Average tons per day per man underground 2/	1/ 7.68	8.55	11.25	6.94
Total number of employees, surface and underground2/	1/ 34	3/ 34	90	79
Average tons per day per man employed2/	6.33	6.77	8.24	5.89
Average tons of coal produced per pound of explosive	4/17.00	(5/)	3.95	6.54
Average tons of coal produced per prop	1.50	See text	9.6	3.5
Total power consumed per ton of coal, kw-hr.	(7/)	8/ 5.2	(7/)	8
Estimated recovery, percent	95	7/ See text	(7/)	85
Size of mine car, tons	1.90	2.6 to 4.0 See text	1.65	1.3

(See footnotes on following page.)

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TABLE 2. - Summary of performance, conveyors - Continued

	Mine			
	23	24-A	24-B and C	24-A, B, and C
Description of mechanization:				
Cutting machines, type	Shortwall	Shortwall	Shortwall	Shortwall
Conveyor, type	9 chain, 6 mobile	Chain	2 shaker, 6 chain	Shaker; chain
Loading method	Hand loaded; 1 scraper	Hand loaded	Hand loaded	Hand loaded
Location of mine	Pennsylvania	Pennsylvania	Pennsylvania	Pennsylvania
Percent of mine mechanized	60	80.2	62.9	70.6
Average daily production from mechanized units, tons	1,279	978	960	1,938
Thickness and dip of coal bed	37 to 42 inches - level	42 inches - level	42 to 44 inches - level	42 to 44 inches - level
Number and hours of shift in mine	3 - 7	3 - 7	3 - 7	3 - 7
Number and hours of shift in tipple	2 - 7	2 - 7	2 - 7	2 - 7
Number of conveyor units	9 chain, 6 mobile	8	9	17
Number of conveyor-unit shifts per day	See text	24	27	51
Average number of men per unit per shift	See text	3.75	3.33	3.53
Man-shifts per day on mechanized units	131	90	90	180
Average tons per day per man on mechanized units	9.76	10.87	10.66	10.76
Total number of employees underground2/	165	114	118	232
Average tons per day per man underground2/	7.77	8.57	8.13	8.35
Total number of employees, surface and underground2/	184	127	130	257
Average tons per day per man employed2/	6.95	7.70	7.38	7.54
Average tons of coal produced per pound of explosive	10.25	8.4	8.4	8.4
Average tons of coal produced per prop	5.25	3.1	6/ 3.2	3.1
Total power consumed per ton of coal, kw-hr.	(7/)	(7/)	(7/)	(7/)
Estimated recovery, percent	85	(7/)	(7/)	(7/)
Size of mine car, tons	2.0	1.4	1.4	1.4

1/ Tonnage from conveyors. 2/ Includes proportion of employees according to percent of mechanization.
3/ Men chargeable to tonnage from conveyors. 4/ Always shooting to an open end. 5/ Cardox used when shooting on shift. 6/ Eight tons per cross bar. 7/ Not available. 8/ Total power underground including mobile loaders and conveyors.

TABLE 3. – Summary of performance of mines in Progress Report No. 2

Mine	Average thickness of bed, inches	Average daily production from mechanized units	Tons per unit per shift	Tons per man-shift: Men on mechanized units	Tons per man-shift: Men employed underground	Tons per man-shift: Total surface and underground employees	Remarks
Mobile loaders:							
15	108	925	115	11.56	10.28	8.11	Loading into cars.
16	312	2,400	300	15.78	11.26	7.32	Do.
17	144	1,442	360	20.0	11.35	9.74	Do.
18	150	1,520	380	23.35	15.04	10.55	Do.
19	48	1,080	180	15.00	9.07	7.65	Do.
20	72	1,176	294	32.66	24.00	17.04	Dual haulage, loading into tractor-trailer units.
Conveyors:							
15	108	215	107	8.26	7.68	6.33	Hand load, chain.
18	150	230	57	10.54	8.55	6.77	Self-loading heads.
21	90	743	93	13.75	11.25	8.24	Self-loading head.
22	42	465	46	8.3	6.94	5.89	Hand load, chain and shaker.
23	37-42	1,263	36	10.02	7.77	6.95	Hand loading on chain and mobile.
24	42-44	1,938	38	10.76	8.35	7.54	Shaker and chain – hand loading.

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Figure 12 is a graph showing the relation of thickness of coal to the tons of coal produced per conveyor shift and was determined by using the weighted averages of the data obtained at the 10 conveyor mines described in Information Circular 7014 and this paper. A straight-line graph shows the tons per conveyor-shift increasing directly as the coal seam increases in thickness and shows no tendency to approach a limit. It appears that the conveyors at the mines studied are operating considerably below capacity. The point located at 30 inches of coal and 58 tons per conveyor shift indicates a much higher output of coal than the average for that thickness. The method of mining at this operation is a modified longwall system that allows an additional number of men to load coal and therefore increases the output per conveyor. The point located at 52 inches thick and 29 tons per conveyor shift is exceptionally low in production per unit shift for this thickness of coal. The distance of this point below the average line represents the loss in tonnage due to time necessarily spent in properly maintaining working places where roof conditions are not good.

In figure 13, curve A is based upon weighted average of men on mechanized units.

This curve indicates that the number of men employed on mechanized units increases at the rate of 60 men per 1,000 tons production. The number of men employed on these units at the mines studied ranges from 31 minimum to a maximum of 89 for 1,000 tons production.

The minimum number of men employed per 1,000 tons is shown on the curve at point 36 men and 1,176 tons. Roof conditions in this mine are excellent and production time is high. When loading in rooms, the wait between vehicles is only approximately 20 percent of the time spent by the loading machine in the room.

Curve B in figure 13, is based upon the weighted average of total underground employees. It is logical that the number of men employed underground should increase with the rise in daily production. More men are needed for ventilation, haulage, and mine and machine maintenance with the present methods of mining. The weighted average curve indicates 88 employees underground per 1,000 tons production. Underground employees include men on mechanized units. The average number of underground employees, exclusive of men on mechanized units, is then 28 per 1,000 tons. However, at the mines studied the number of underground employees exclusive of those on mechanized units ranged from 11 men to 56 men per 1,000 tons. The mine having the minimum number of men is 100 percent mechanized, working places are concentrated, little timbering is required on main entries, and a dual system of haulage is used, which approaches continuous flow of coal from face to tipple. Large cars of 5 tons capacity are used from a transfer station to the mine bottom, where the coal is transported to the tipple by a conveyor belt. (Refer to mine 20.) A comparison of this mine with the mine employing the maximum number of men per 1,000 tons would not be fair to the latter, which is only 14 percent mechanized. Roof conditions are bad, which requires close timbering on main haulageways; abnormal dips in

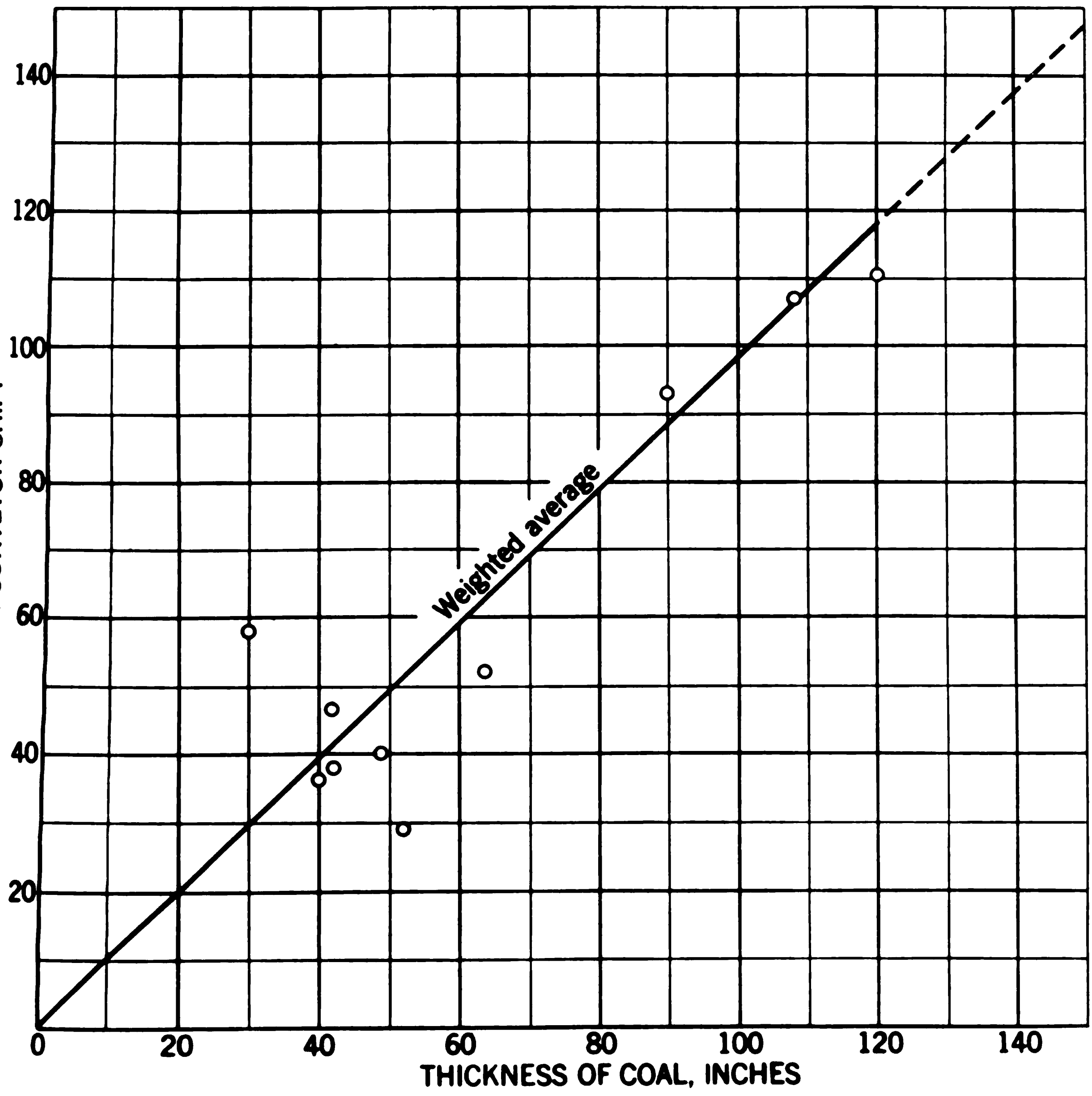

Figure 12.– Relation of tons per conveyor shift to thickness of coal bed

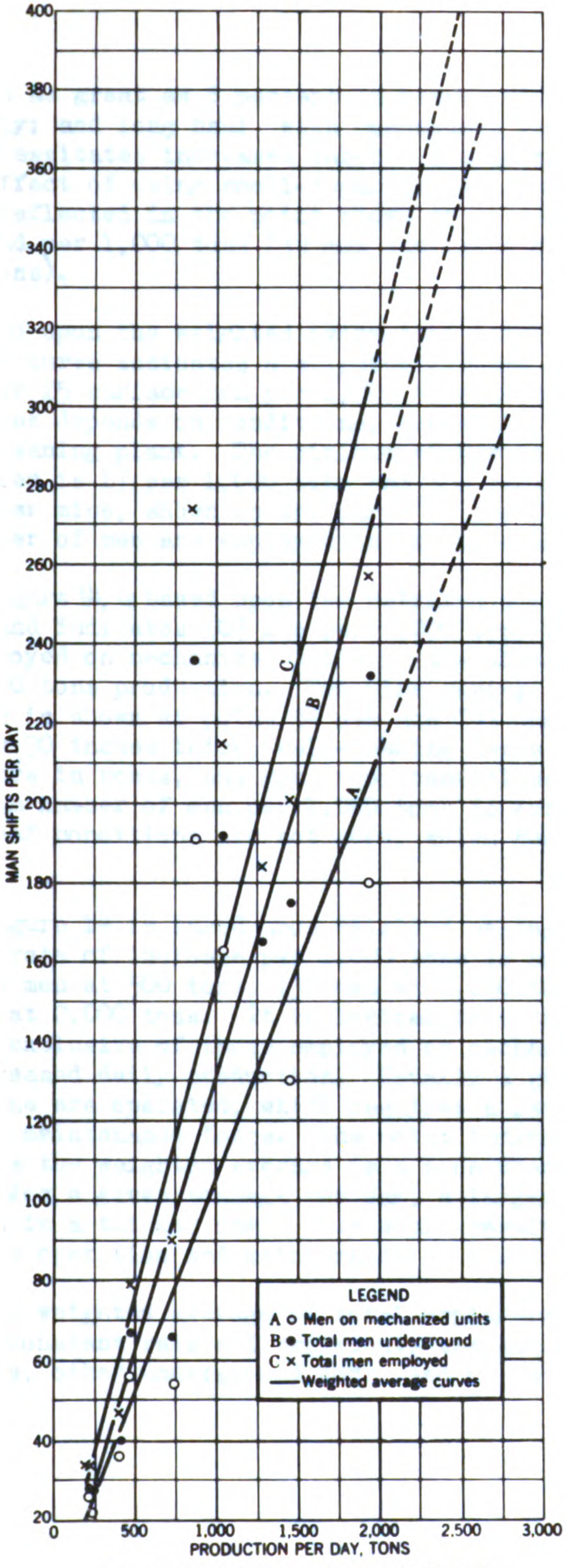

Figure 14.–Relation of man shifts to production per day with conveyors

the bed, sometimes as great as 8 percent in rooms, affect the operation of conveyors adversely; and long haul, with consequent high maintenance of haulage roads, necessitates increased labor. (Refer to point 67 men, 500 tons.) The effect of using small-capacity cars, poor roof conditions, and long haul is reflected in the point shown at 75 men and 584 tons or 128 men underground per 1,000 tons (39 men exclusive of those on mechanized units per 1,000 tons).

Curve C, is based upon the weighted average of total employees, underground and surface. This curve indicates a weighted average of 113 men per 1,000 tons production, or 25 surface men per 1,000 tons production. The number of surface employees depends on conditions, especially whether the mine is equipped with a cleaning plant. The minimum number of surface employees at the mines studied is 17 per 1,000 tons and the maximum is 43 per 1,000 tons. At the latter mine, shown on the curve at the point 100 men and 584 tons, a large number of men are employed in the cleaning plant.

Curve A of figure 14, is based upon the weighted average men employed on mechanized units and indicates 107 men per 1,000 tons production. The number of men employed on mechanized units at the mines studied ranges from 72 to 229 per 1,000 tons production. The mine having the minimum number of men per 1,000 tons is shown at point 54 men and 743 tons. The coal bed at this mine averages 90 inches thick, self-loading heads are used, grade is toward the conveyors in rooms, and good roof conditions exist. The mine showing the maximum number of men per 1,000 tons is working in a 30-inch bed of coal and roof conditions are not good, which necessitates additional men for timbering.

Curve B of figure 14 is based upon weighted average of men employed underground. The rate of increase per 1,000 tons is not constant. The curve indicates 63 men at 500 tons, 132 men at 1,000 tons, 205 men at 1,500 tons, and 280 men at 2,000 tons. It is logical that the number of underground employees, exclusive of those employed on mechanical units, should increase with increased daily production. Usually a greater number of sections in the mine are operated, which requires a larger ventilating, track, timber, and maintenance force. The point indicating the highest number of men above the weighted average is a mine where the coal bed is 30 inches thick. For a given tonnage per day, a larger area would be opened in a thin bed than in a thicker one. This would result in the employment of more men for the operation and maintenance of the mine.

Curve C is the weighted average of total employees. This curve does not increase at a constant rate and represents the sum of the men employed on mechanized units, other underground work, and on surface operations.

CONCLUSIONS

The rapid development of loading equipment adds to the complexity of mechanical mining. Careful planning is required for the return of capital invested in equipment before obsolescence occurs. Coordination of every operation is necessary, and this can be accomplished best by using the data collected from detailed time studies of every phase of the mining cycle. The curves of figures 11 and 12 indicate that the full capacity of the loading equipment is not being employed. This may be due in part to adverse physical conditions, but a study of methods of coordinating transportation with loading should show the way to increase the output per unit and hence to reduce the cost per ton.

Rapid development of entries is essential to maintain maximum production, particularly in mines working thin beds where haulageways must be "brushed" for height. This can be accomplished best by mechanization.

Scraper units have been used to advantage in driving brushed entries in low coal. The records of rapid development are described under mine No. 25, where both coal and brushing are loaded from over 100 feet of heading from one setting of the scraper unit.

Conveyors are particularly suited to mining thin beds of coal but are used to advantage in mining thick beds on heavy pitches (see mine No. 2

Mobile-type loading machines are best suited to the mining of level beds of coal or to working on the strike of pitching beds. However, they have had limited use in working places where the pitch was as much as 12-1/4 percent upgrade and 23 percent downgrade. (See mine No. 17.) Mobile loading units are being used in beds 42 inches thick (which is the minimum observed).

Mechanization of mines results in the introduction of machinery to suit certain physical conditions, height of coal, character of roof and bottom, dip of bed, and production desired. However, the ultimate success of mechanization depends upon a thorough understanding of the problems involved and coordination of all operations - cutting, shooting, timbering, loading, and transportation. The men working with the machines should be properly trained to use them and educated to conduct the operations safely.

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